HUMAN AND ECOLOGICAL RESPONSES TO THE NORTHERN WHITE RIVER ASH ERUPTION

By

Holly A. Smith, B.A.

A Thesis Submitted in Partial Fulfillment of the Requirements

for the Degree of

Master of Arts

in

Anthropology

University of Alaska Fairbanks

May 2020

APPROVED:

Joshua Reuther, Ph.D., Committee Chair
Nancy Bigelow, Ph.D., Committee Member
Jamie Clark, Ph.D., Committee Member
Patrick Plattet, Ph.D., Chair, *Department of Anthropology*
Todd Sherman, M.F.A., Dean, *College of Liberal Arts*
Michael Castellini, Ph.D., *Dean of the Graduate School*

ABSTRACT

The White River Ash northern lobe (WRAn) volcanic eruption deposited a blanket of tephra (volcanic ash) along the Yukon-Alaska border ~1625 cal BP (calibrated years before present). Currently, there has been limited investigation into the effect of this natural disaster on the environment and local hunter-gatherer populations. This research seeks to analyze and explore the potential ecological and cultural responses to the WRAn event.

To address this question, paired archaeological and palynological studies bracketing the WRAn were conducted. Excavations at the Forty Mile/Ch'ëdä Dëk Territorial Historic Site in the Yukon (LcVn-2) revealed a multicomponent site including cultural deposits dating to approximately 1500 and 2000 years ago, with a band of WRAn ash separating them. The focus of the project was to identify similarities and differences in artifactual and faunal assemblages and feature types between cultural occupations pre- and post-tephra deposition that could indicate variations in site use, hunting practices, and tool manufacture. A decadal-scale pollen analysis spanning ~80 years before and after the WRAn tephra fall was conducted on a lake core collected near Eagle, Alaska, to explore the potential environmental impacts of the tephra deposition on the landscape.

Results from this project suggest that the WRAn eruption did not create a prolonged negative environmental or cultural impact. At the study location, which experienced at least ~1 cm of tephra deposition, there is a prompt reoccupation of the Forty Mile Site, with multiple subsequent occupations, displaying a resilient population that was able to adapt to the fluctuating environmental surroundings. Similarly, the pollen displays a period of ~5 years of reduced influx and productivity, followed by spikes of abundance before returning to pre-eruptive comparable levels ~35 years after the WRAn. In this thesis, I argue that no hiatus in cultural occupation occurs following the WRAn tephra deposition and the archaeological assemblage displays characteristics in accordance with general cultural transitions occurring in southwestern Yukon and interior Alaskan archaeology.

TABLE OF CONTENTS

Title Page ... i

Abstract ... iii

Table of Contents ... iv

List of Figures ... vii

List of Tables ... viii

List of Appendices ... x

Acknowledgments ... xi

Chapter 1: Introduction ... 1
- 1.1 Case Study Locations ... 3
- 1.2 Research Questions and Expectations ... 3
- 1.3 Thesis Organization ... 7

Chapter 2: Theoretical Approach ... 9
- 2.1 Responses to Environmental Catastrophes ... 9
  - 2.1.1 Evaluating Responses to Volcanic Events ... 10
    - *2.1.1.1 Environmental Responses* ... 11
    - *2.1.1.2 Cultural Responses* ... 16
    - *2.1.1.3 Ecological Expectations Following the WRAn* ... 18
- 2.2 Human Behavioural Ecology ... 21

Chapter 3: Background of the Study Area ... 26
- 3.1 Regional Environment ... 27
  - *3.1.1 Geography* ... 27
  - *3.1.2 Climate* ... 28
  - *3.1.3 Ecology* ... 28
  - *3.1.4 Volcanism* ... 29
    - *3.1.4.1 White River Ash* ... 29
- 3.2 Regional Culture History ... 32
  - 3.2.1 Ethnographic Context ... 32
  - *3.2.2 Territory* ... 34
    - *3.2.2.1 Relationships Between First Nation Groups* ... 34
    - *3.2.2.2 Population* ... 35
    - *3.2.2.3 Seasonal Round* ... 36
  - *3.2.3 Archaeological Background* ... 37
- 3.3 Case Study Localities Background ... 39
  - *3.3.1 Forty Mile Site (LcVn-2)* ... 40
    - *3.3.1.1 Previous Fieldwork and Excavations* ... 42
  - *3.3.2 6-Mile Lake* ... 47

Chapter 4: Materials and Methods ... 49
- 4.1 Pollen Analysis ... 49

4.1.1 Site Selection 49
4.1.2 Processing and Preparation 50
4.1.3 Pollen Analysis 51
4.1.4 Radiocarbon Sampling 51
4.1.5 Age Model 52
4.1.6 Pollen Diagrams 53
4.2 Archaeological Excavation 53
4.2.1 Site Selection 54
4.2.2 2017 Excavation Methods 54
4.2.3 Artifact Collections 55
4.2.3.1 2017 Excavation 55
4.2.3 Radiocarbon Samples 56
4.2.4 Variables Considered 57
4.2.4.1 Chronology and Stratigraphy 57
4.2.4.2 Faunal 59
4.2.4.3 Lithic Debitage and Artifacts 61
4.2.4.4 Spatial Control 64
4.2.5 Limitations 64
Chapter 5: Results 66
5.1 The 6-Mile Lake Pollen Core 66
5.1.1 Age Model 66
5.1.2 Percent and Concentration Data 68
5.2 Forty Mile Site (LcVn-2) Excavations 73
5.2.1 Stratigraphy and Site Chronology 74
5.2.2 Spatial Distribution 78
5.2.3 Formal Tools and Other Artifacts 82
5.2.4 Faunal Analysis 83
5.2.4.1 Size Class and Identifiable Fauna 84
5.2.4.2 Taphonomy 88
5.2.5 Lithic Analysis 89
5.2.5.1 Raw materials 90
5.2.5.2 Debitage Attribute Analysis 93
Chapter 6: Discussion and Conclusions 101
6.1 Vegetation Responses to Tephra 101
6.1.1 Specific Pollen Taxa 103
6.1.2 Seasonality 105
6.1.3 Effects of Environmental Change for Wildlife 105
6.2 Human Responses to Tephra 106
6.2.1 Faunal Material and Subsistence 107
6.2.1.1 Tat'tla Mun Site Faunal Comparison 109
6.2.2 Lithic Material 110
6.2.3 Land Use and Site Function 112
6.2.4 Cultural Chronology Context 113
6.3 Conclusions on the Effects of WRAn 116

References Cited 118

Appendices 134

LIST OF FIGURES

Figure 1.1 Map of White River Ash distribution 2

Figure 3.1 Map of study area and locations 26

Figure 3.2. Ecoregions map of the study area 27

Figure 3.3 The Native Peoples and Languages Map of Alaska and the Yukon 33

Figure 3.4 The Forty Mile Site area 40

Figure 3.5 The Forty Mile Site with the North and Mission (or ACM) localities identified 41

Figure 3.6 Map of Historic Townsite of Forty Mile and 1998 field tests 43

Figure 3.7 Map of ACM locality 2003 field tests and excavation units 45

Figure 3.8 Map of ACM locality 2004 excavation units 46

Figure 3.9 6-Mile Lake area 48

Figure 4.1 Image of 10-C D-1 during data sampling. 50

Figure 5.1 Age model for 6-Mile Lake core 10C 68

Figure 5.2 Summary pollen diagram of the percent and concentration data 70

Figure 5.3 Pollen influx (grains/cm^2/yr) 71

Figure 5.4 Site map from 2017 excavation combined with previous work 74

Figure 5.5 Block 1 stratigraphic profile 76

Figure 5.6 Calibrated age ranges for the Forty Mile Site cultural components 77

Figure 5.7 Block 1 West wall stratigraphy 78

Figure 5.8 Spatial distribution of 2017 excavtion by cultural component 79

Figure 5.9 Relative frequency of raw material types by component groupings 91

Figure 5.10 Relative frequency of raw material quality by component groupings 92

Figure 5.11 Occurrence of A-prime obsidian in Alaska-Yukon 93

Figure 6.1 Map of Forty Mile Site and Tat'tla Mun 109

List of Tables

Table 2.1 Impact of tephra thickness on plants at Mount St. Helens ... 19

Table 3.1 First Nation seasonal round ... 37

Table 3.2 Cultural components identified at the ACM locality in 2003 and 2004 ... 46

Table 4.1 Previous radiocarbon samples from the site ... 56

Table 4.2 Radiocarbon samples sent from 2017 excavation for AMS dating. ... 57

Table 4.3 Size class categories as modified from Thomas (1969) ... 60

Table 5.1 Radiocarbon dates from 6-Mile Lake ... 67

Table 5.2 Influx values for pollen at specific intervals ... 72

Table 5.3 Radiocarbon dates for the Forty Mile Site ... 77

Table 5.4 Artifact counts for the 2017 excavation ... 78

Table 5.5 All formal tools and artifact types recovered from the Forty Mile Site ... 82

Table 5.6 Size class NISP and percentage for the entire Forty Mile faunal assemblage ... 84

Table 5.7 NISP from faunal assemblage ... 85

Table 5.8 NISP of identifiable moose and caribou bones by cultural components ... 87

Table 5.9 Taphonomic variables considered and the results ... 88

Table 5.10 Assigned raw material codes, quality, descriptions, and rock types ... 91

Table 5.10 Obsidian artifacts analyzed ... 93

Table 5.11 Flake type by component groupings ... 94

Table 5.12 Technology type by component grouping ... 95

Table 5.13 Occurrence of cortex by component groupings ... 95

Table 5.14 Standard deviations and means for length ... 96

Table 5.15 Standard deviations and means for width ... 96

Table 5.16 Standard deviations and means for thickness ... 96

Table 5.17 Standard deviations and means for weight ... 96

Table 5.18 Multivariate analysis of metric attributes of the lithic artifact data set 97

Table 5.19 Thermal alteration by component groupings 97

Table 5.20 Erailure scares by component groupings. 98

Table 5.21 Bulbs of force by component groupings 98

Table 5.22 Lipping by component groupings 98

Table 5.23 Flake termination by component groupings 99

Table 5.24 Standard deviations and means for platform width 99

Table 5.25 Standard deviations and means for platform thickness 99

Table 5.26 Platform preparation type by component groupings 100

Table 6.1 Forty Mile and Tat'tla Mun faunal comparison of NISP values 110

LIST OF APPENDICES

Appendix A: Pollen Sample Processing Sheets 134

Appendix B: Radiocarbon Dates - Pollen Samples 136

Appendix C: Age Model Settings 140

Appendix D: Lithic Analysis Raw Material 141

Appendix E: Radiocarbon Dates - Archaeology Samples 142

ACKNOWLEDGMENTS

I have so many people to thank for their assistance and support in completing this research. First, I would like to thank my committee for their efforts, patience, and encouragement throughout this process. Ben Potter for helping me to mould this project from a few random ideas and opening my mind to potential avenues of research. Josh Reuther for providing steady guidance, feedback, and clarity whenever requested and finding Alaskan fieldwork opportunities for me that always included an abundance of coffee. Nancy Bigelow for teaching me everything I know about pollen, spending endless hours in the lab assisting me, and always pointing out those handsome pollen grains. Jamie Clark for engaging classes, extensive edits, unending support (even when on sabbatical), and for joining my committee at the last minute to help me in the final push. I would also like to thank the entire anthropology faculty at the University of Alaska Fairbanks for accepting this humble Canadian into your department, and imparting on her your wisdom and sharing your time. I am a better archaeologist and human for it.

Funding for this project was provided by numerous sources and I am truly appreciative for each of their support. The University of Alaska Fairbanks for funding me as a graduate student. To the Government of Yukon, Archaeology Program and Tr’ondëk Hwëch’in First Nation (THFN) Heritage Department for financing the archaeological excavation and the radiocarbon analysis of the site. The Museum of the North Otto Geist Fund and Frison Institute Patrick Orion Mullen Fund who assisted in paying for radiocarbon analysis of the lake core, lab supplies, and travel between Alaska and the Yukon.

For the fieldwork logistics I owe a great deal to the heritage staff at THFN and the Government of Yukon. Both departments put in countless hours planning, coordinating, budgeting, and supporting me throughout the process and this project would not have been possible without their efforts. Lee Whalen and Alex Brook for crew planning, on-site logistics, and the best field accommodations I have ever been provided. Christian Thomas is responsible for inspiring/pressuring me to return to Forty Mile and use this site as a cornerstone for my research. His passion, knowledge, and enthusiasm for, not only Forty Mile, but all Yukon archaeology is infectious and motivating, and for that I am eternally grateful. To the 133a Industrial Staff, thank you immensely for being a sounding board, a mentor, and going out of your way to assist me throughout the fieldwork, analysis, and writing phases.

My field crew included Dawn, Luke, Gavin, Sammy, Marshall, Lee, Christian, Nansen, and KC. Unending thanks to YG STEP student Dawn Bohmer, for being my right hand woman, the Veronica to my Betty. This amazing young woman was beside me every step of the fieldwork (quite literally) and always went above and beyond whatever the task entailed. Thanks to Nansen from Historic Sites for enthusiastically jumping in, and to Barb for lending him to me. Special thanks to KC the canoe guy for coming out with a positive attitude, and volunteering his time after running into some archaeologists at a campground. And to Joe and Albert, the Forty Mile Site caretakers, for doing an excellent job maintaining the site and keeping an eye out for everyone. Gratitude goes to Anna Burchfield for volunteering countless hours helping me cross-reference and rectify the artifact cataloguing, and to Misha Donohoe for assisting in transforming my wall profiles into beautiful digital creations in a pinch. Many thanks to TJ Hammer, and all the field participants for their previous work at the site, for building a solid foundation for me to expand on.

Acknowledgements are due to all of my fellow grad students, some of whom became my pseudo-family while embarking on this academic adventure. Whether it was weekend hikes, long nights in the lab, sharing classes, or surviving comps, our struggles and celebrations brought us closer and I'm thankful for each and every one of you. Special mention to Kate, I literally don't know where I would have been without you. You are such a rock, and one of the most driven and intelligent people I know. Thank you for your endless guidance, kind heart, and long runs followed by brunch. And to Hilary for being the most accepting, compassionate, and clever woman I know, and for always making time for the people you care about. I would have been lost without your support, edits, and camaraderie throughout the data collection, writing, and defence preparation phases. (We totally got this!)

And last, but certainly not least, to all my family and friends in the Yukon, Alaska, Ontario, and scattered abroad, thank you for your continued support in everything that I do. Whatever adventure I choose to tackle I know I have a strong foundation of love, support, and encouragement behind me, with just enough sarcasm and judgment to keep me constantly motivated, growing, and improving.

Chapter 1: INTRODUCTION

Natural disasters are often defined as catastrophes due to their all-encompassing ability to disturb the ecological and cultural landscape, especially over prolonged periods of time. These events can produce a wide range of effects both spatially and chronologically and include events such as volcanic eruptions, earthquakes, hurricanes, drought, tornadoes, and tsunamis. In recent anthropological studies, focus has shifted from the destructive force on the environment, to the social, physical, and sometimes even mental disruption to humans (Oliver-Smith 1999). Natural disasters are a meaningful area of study because they test the adaptive resilience of people within their total environment (Hoffman and Oliver-Smith 1999). Hunter-gatherer groups are particularly reliant on their local environment for subsistence; therefore, when this connection is disrupted following a natural disaster it creates an opportunity to study their behaviour and responses to these events. These responses can inform us on prehistoric risk management behaviours.

Human responses to naturally occurring events, such as volcanic eruptions, display the adaptability and resilience of societies, and their connection to their physical environment. The level of impact that a tephra (volcanic ash) deposition has on an ecosystem depends on a number of factors including the magnitude of the eruption, amount of tephra accumulated, season of the eruption, local environment, and the ecosystem's ability to respond to environmental stress (Dilley 1988:80). Human responses to these environmental impacts can vary considerably depending on vegetation and fauna recovery time, which resources are highly valued, the seasonal round, recovery time, trade relationships, and population size. There are numerous examples of archaeological sites that have tephra beds, with subsequent occupations overlying these deposits, providing evidence of the persistence of social groups to re-occupy their homelands (Torrence 2016). On the other hand, there are sites that are buried, with successive occupations occurring much later (Grayson and Sheets 1979). Hypothetical effects could include depopulation and abandonment of the region, reoccupation by the same groups utilizing similar or different technologies, or occupation by different populations taking advantage of new niche creation. These human responses reflect the effects of stresses within the ecosystems and on resources that prehistoric groups depended upon.

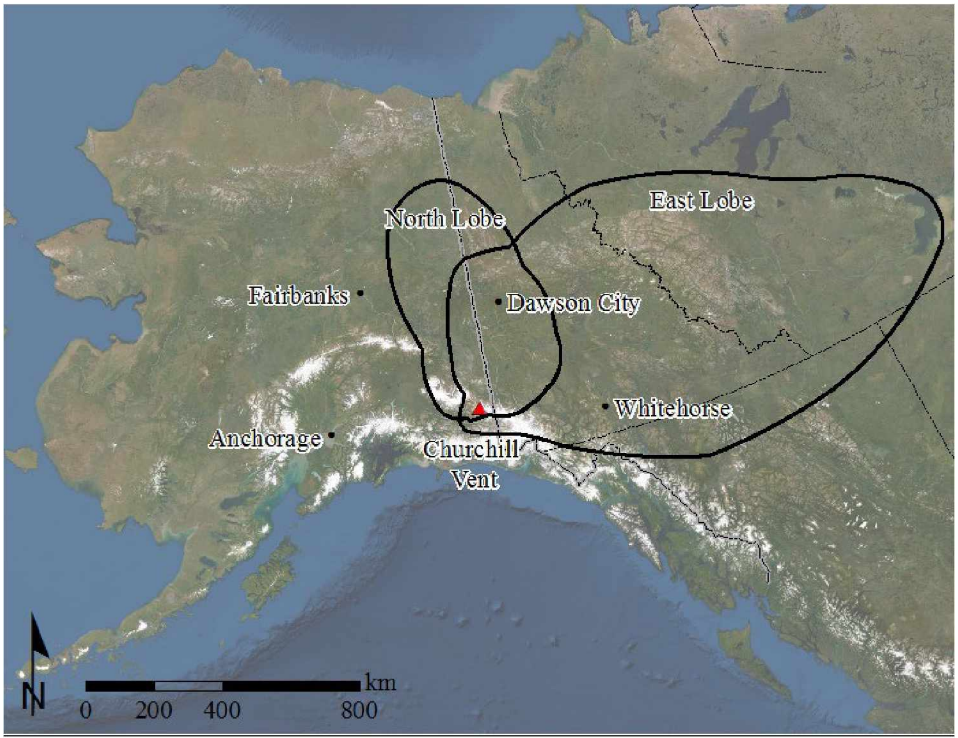


Figure 1.1 Map of White River Ash distribution. Location of the Churchill Vent and the distribution of Northern and Eastern Lobes of the White River Ash (distributional data from Mulliken et al. 2018).

The dual volcanic eruptions that occurred in the Mount Churchill vicinity, circa 1625 cal BP (Reuther et al. 2019) and 1147 cal BP (Clague et al. 1995) were noteworthy events in the geologic record of the Yukon and eastern Alaska (Figure 1.1). These events left behind widespread tephra deposits known as the White River Ash northern lobe (WRAn) and eastern lobe (WRAe), respectively. There have been numerous geologically-focused studies on the age, size, source, distribution, tephra thickness, and effects of these two volcanic eruptions (Lerbekmo and Campbell 1969; McGimsey et al. 1992; Richter et al. 1995; Robinson 2001; Jensen et al. 2014; Davies et al. 2016, to name a few), which have assisted in providing the scale and context for anthropological and ecological studies. The WRAe tephra created a larger footprint on the environment and is theorized to have a lasting impact on the affected populations by creating a less ecologically stable area of land resulting in relocation, language differentiation, and innovative technological adaptations (Workman 1974; Derry 1975; Workman 1979; Moodie et al. 1992; Hare et al. 2004). Specific investigations into the human responses to the WRAn are lacking (Mullen 2012). These volcanic events occurred during a critical time period of cultural transition identified in southwestern Yukon, from the long-lived middle Holocene Archaic culture to the Late Prehistoric Period. As each of these volcanic eruptions varied in size, region, and scope, it is important to study their effects independently. It is the hope of the researcher that further attention is given to the WRAn-affected region and examinations continue beyond this study.

This multidisciplinary project contributes to both the natural and cultural knowledge of the study area and the broader region by combining pollen data (from 6-Mile Lake) with archaeological data (from the Forty Mile Site) as proxy data for environmental and cultural change, respectively. Using both datasets, we are able to further understand the environment in which Indigenous populations lived, and to identify cultural and vegetative responses that occurred following the WRAn eruption. It also contributes to a better understanding of how people in the past responded to disruptions to or limitations within to their local environment.

1.1 Case Study Locations

Two locations within the impact zone of the WRAn were chosen in order to provide the archaeological and ecological contexts in this study: the Forty Mile Site (LcVn-2) located at the confluence of the Yukon and Forty Mile Rivers in Yukon Territory, and 6-Mile Lake located near Eagle, Alaska. Both sites exhibit approximately 1 cm of buried tephra deposition. Excavations at the Forty Mile Territorial Historic Site (LcVn-2) were previously conducted between 1998 and 2004 (Hammer 1999, 2000, 2002, 2003; Thomas 2004, 2005); however, a formal analysis of the entire site was not conducted until this project. Additional excavations were undertaken in 2017 to contribute further understanding to the post-ash components. Previous prehistoric materials from the site were borrowed from the Yukon Heritage Department and used in this analysis. In addition, high-resolution analysis of the pollen record bracketing the WRAn was conducted on samples drawn from a lake core collected in 2010 from 6-Mile Lake by researchers at the University of Alaska Fairbanks' Alaska Quaternary Center. The endeavour to focus on ~80 years before and after the WRAn deposit provides an understanding of the vegetative responses to tephra deposition in the region.

1.2 Research Questions and Expectations

The objective of this research is to analyze the human and environmental responses to the WRAn event in order to gain a better understanding of how people in the past responded to a volcanically disturbed subarctic landscape. Human behavioural ecology (HBE) provides a theoretical framework to examine this interaction for hunter-gatherers in the region. Addressing this involved conducting pollen analysis and additional archaeological excavations in the tephra affected area. The pollen data provides environmental context within the local landscape at the time before and after the WRAn eruption and insight into the ecological responses. The archaeological data provides context for the cultural setting before and after the ash fall and offers opportunities to analyse the human responses. To address this objective, four specific research questions and expectations are investigated:

- How did tephra affect vegetation? Following the WRAn eruption, do plant taxa recover and repopulate the area in similar proportions and abundance? If so, how long does it take?

Pollen analysis is a technique principally employed for long-term reconstructions of vegetation and climate (Seppä 2007). In this study, high-resolution (decadal-scale) analysis of the pollen record was conducted in order to capture subtle variability in the local environment. This scale allows for a more detailed ecological assessment and aids in understanding the environmental effects of tephra deposition in the area. These responses are then compared to known vegetation succession on modern volcanic landscapes. The high-resolution pollen study is coupled with a chronological assessment of the lake core, which provides insight into the direct timing of vegetative fluctuations. This provides context to the pre-WRAn local environment, the responses to the tephra, and the degree/rate of recovery. This timeline sheds light on how to interpret the overall effects of this eruption to the flora, fauna, and people inhabiting the area.

Given what is known from research on plant responses to tephra deposition it is possible to generate a number of expectations. Succession and recovery of the landscape following tephra deposition depends on a number of ecological factors (Swanson and Crisafulli 2018), and is heavily influenced by the tephra thickness, texture, and frequency of deposition (Antos and Zoebel 2005). Based on the knowledge that the WRAn study area experienced less than 10 cm of tephra deposition, is located within a subarctic boreal forest landscape, in a valley in close proximity to two major watercourses, and had not experienced frequent tephra depositions, we should expect to see limited long-term adverse responses and a rebound of the local vegetation within a few decades. Studies where tephra deposition is less than 10 cm thick conclude that the majority of species survive and experience limited long-term effects (Griggs 1918; Grishin et al. 1996; Dale et al. 2005; Swanson and Crisafulli 2018). The most significantly affected species would include some herbs, moss, and lichens due to their diminutive size; however, it has been shown that they are able to survive thin layers of tephra and eventually return to pre-eruption abundance.

- What are the effects on fauna? How would the changes to the vegetative landscape affect the local fauna? What animals would be most and least impacted by tephra deposition? Are these short-term or long-term effects?

Similar to vegetation responses, animals respond variably to tephra deposition, based on their preferred habitat and food resources. Small mammals who live in burrows are offered some amount of protection from tephra (MacMahon et al. 1989), mammals who graze are affected by food resources covered in ash causing significant tooth wear (Jagger 1945; Trowbridge 1976), browsing mammals could feed successfully (Riehle et al. 2000) but the ingestion of toxic chemicals would be detrimental (VanderHoek and Nelson 2007), carnivores are influenced by the survivorship of their prey (MacMahon et al. 1989), and fish species are influenced by spawning seasons and flow rate of the water (Riehle et al. 2000). This question is addressed both theoretically based on the vegetative responses, and through the archaeological record of faunal remains.

Based on the expected vegetation responses, certain species of animals would experience negative effects. Ethnographically, one of the highest-ranked food resources for hunter-gatherers in the study location is caribou. Given that caribou are grazers and that lichen would suffer negative effects from tephra fall, we would expect to see an avoidance of the study area for this species. In comparison, moose, being browsers, would experience negative effects only if the tephra was thick enough to impede shrub growth. In addition, it is possible that certain fish species would experience decreased numbers depending on preferred spawning locations and amount of tephra flowing in the rivers. An increase in diet breadth by the people would likely result, as small mammals and browsing ungulates like moose would become more heavily utilized as caribou were encountered less. If the WRAn tephra deposition affected the local fauna, this would in turn influence the acquisition of resources by local hunter-gatherer population by dictating which species would be available and their abundance on the landscape.

- Were there human behavioural responses? Do settlement patterns, faunal remains, and lithics at the Forty Mile Site indicate responses to WRAn tephra deposition? Do environmental impacts generate sustained variation in site use, mobility, toolstone resource procurement, hunting practices, trade, or tool manufacture?

To date, there have been limited archaeological excavations in the tephra fallout zone of the WRAn. Investigations in the broader region suggest a cultural transition occurred ~1250 years ago, with researchers utilizing the fall of the WRAe lobe as the indicator for this shift (Heffner 2002). Although very similar, a handful of differences have been noted, including a reduction in site size, toolkit modifications, and an increase in fire-cracked rock. As sites are limited in the region during this time period, it could be that multiple environmental and/or social impacts contributed to this cultural transformation. Additional excavations were conducted at the Forty Mile Site in order analyze site use, faunal remains, and lithics present at the site. These artifacts provide the basis for the analysis of the site and contribute to determining responses occurring after the WRAn ash fall. As the site is highly stratified and chronologically controlled, differences in the cultural components are delineated to a higher resolution than other sites in the vicinity.

Based on established HBE optimality models of diet breadth, patch choice, mobility strategies, and resource scheduling, I would expect a certain amount of response in the archaeological record. Variation in faunal remains would indicate a change in diet breadth as addressed above. A change in mobility or territory could produce an influx in exotic lithic material (Binford 1979), or a prolonged use of the site could occur if it acted an oasis or reliable resource-gathering patch during a time of unpredictability (Binford 1980). This could also affect the level of mobility, carrying capacity of a group, and patch residence time. It is also expected that resource scheduling would vary as the landscape would be modified by tephra deposition and cause normally abundant resources to stagnate or be reduced for a period of time. This could mean that some plants and animals would be targeted upon encounter and not necessarily during the ideal time of year, or perhaps species less affected by tephra became highly targeted.

- Was the Middle-Late Holocene cultural transformation caused by responses to the ashfall? Given what is known about the cultural chronology of the region, does the Forty Mile Site archaeological record align with the established Taye Lake Phase and Late Prehistoric Period in terms of material culture and settlement patterns?

This question is addressed by comparing the results of the lithic and faunal analysis to contemporary sites and cultural chronologies in the region to assess if changes at the site are the result of localized cultural responses to WRAn tephra fall or trends of cultural innovation and advancement occurring on a wider scale in the region. This time period encompasses a transition in material cultural and a profound shift in human behaviours that occur throughout the northern subarctic. Based on the work of archaeologists in both southwest Yukon (Workman 1978; Hare 1995; Hare et al. 2008) and interior Alaska (Anderson 1968; Dixon 1985; Anderson 1988; Esdale 2008) that have established cultural chronologies in the region, it is expected that the Forty Mile record would follow similar forms of settlement pattern and material culture changes that have been indicated during the transition of these phases. These chronologies are considered alongside concepts of intersite variability, technological transition, and mobility identified throughout the late Holocene (Potter 2008a; 2008b; Hare et al. 2012).

It is expected that the archaeological remains will provide evidence for some short-term adaptations to the WRAn in the cultural component immediately following the event, but overall display continuity with the chronology of the area. In terms of the lithic analysis, increased mobility would be expressed by an increase of exotic raw materials whereas persistence of local materials and high rates of cortex would represent no change in mobility or possibly areas of refugia. It would be expected that the lithic debitage would reflect longer-term campsites (lower quality raw materials and *ad hoc* tool maintenance) prior to the ashfall and smaller short-term campsites (multiple lithic sources, higher quality raw materials, more evidence of tool maintenance) afterwards due to inconsistent food resources. This would also be reflected in the faunal record with a higher diet breadth and a change in focus to lower ranked prey following the eruption. The archaeological data at the site is examined by component and pre-/post-ash assemblages to determine if cultural adaptations are perceptible, and then compared to the literature of the region.

1.3 Thesis Organization

This thesis is divided into six chapters. Chapter Two outlines the theoretical approach utilized in this research. This includes an overview of ecological and anthropological responses to volcanic events and expectations for the WRAn eruption, as well as the framework of human behavioural ecology theory and models employed in this analysis. Chapter Three discusses the background of the study area and presents the regional environment, cultural history, and introduces the case study locations in further detail. The material and methods for both the pollen analysis and archaeological excavation are discussed in Chapter Four. Chapter Five presents the results of the analysis of the pollen analysis including the age model, percent and concentration data, influx data, and the archaeological analysis including the stratigraphy and chronology of the site, spatial distribution, faunal specimens, and lithic artifacts. Chapter Six discusses the results, postulates the effects of the WRAn within the context of regional models and chronologies, and offers directions for future research.

Chapter 2: THEORETICAL APPROACH

2.1 RESPONSES TO ENVIRONMENTAL CATASTROPHES

For the most part, the general framework in which anthropologists have studied the effects of natural disasters on people is in relation to the degree of cultural change that resulted. Two research questions often examined include whether populations show simple adaptations or grand-scale modifications to changes in landscape and resource distributions, and if these changes endure or if people reverted back to previous behaviours (Hoffman 1999). The range of potential impacts seems to be of greatest interest in anthropological natural disaster studies (Sheets and Grayson 1979; Oliver-Smith and Hoffman 1999; Grattan and Torrence 2010; Fitzhugh et al. 2016); however, a few considerations are relevant to note. The degree to which cultures are affected can also be guided by a number of factors including, previous social stability, human population size, mobility or flexibility in settlement and subsistence systems, damage caused to the landscape/resources, time between eruptive events, and areas of refuge. Each of these factors will contribute to the whole picture of how disastrous the event will be to the population.

The study of the ecological impacts of volcanic eruptions through the archaeological record gives researchers the opportunity to see the long-term responses to these punctuated events and assess if their impact created short-term coping mechanisms or long-term cultural shifts. By expanding our reach into the past, we are able to widen our research parameters and view not only recent environmental and human responses, but prehistoric ones as well (Grayson and Sheets 1979). In addition, the insights gathered from long-term impacts "may provide a better means of searching for theoretical statements concerning how people respond to those disasters… the archaeological record provides a series of replicated experiments on the effects of volcanism on people that is not available from modern times" (Grayson and Sheets 1979:629). This information assists in disaster management planning for people that live in high impact zones today.

The focus of natural disaster studies is typically on the risk that these events pose to societies. VanderHoek (2010) suggests that risk management studies were previously split into two types, ones undertaken by earth scientists who focus on the physical properties of the natural event, and ones conducted by social scientists who focus on the short-term cultural effects of the disaster. These approaches have become more integrated, as researchers came to understand that not all major ecological events had catastrophic effects on human populations and that humans respond to environmental change in extremely diverse ways. This integrated research approach makes it possible to apply knowledge gained on this topic to the past, present, and future. Multidisciplinary research, especially when combining the earth sciences and social sciences, strengthens the conclusions and creates a more robust risk assessment.

While applying concepts from disaster research to the present, it is critical to frame and apply them properly. "The danger, however, is that some scholars have gone too far and are making a simplistic analogy between modern concerns about disasters and potential effects in the past. This has led to the adoption of a dangerously uncritical approach when hypothesising the importance of past extreme environmental events" (Grattan and Torrence 2010:4). For example, the level of destruction and the responses of the people living in modern day Hawaii may not be comparable to the White River Ash north eruption ~1625 cal BP years ago. The analogy must be framed in a way that reflects the resource strategies, landscape use, and settlement patterns of the individual groups and cultures. It is possible to apply the general concepts and knowledge gained from analogous eruptions, including those along the Alaskan Peninsula and Mount St. Helens, in order to understand the potential environmental and anthropological responses to the WRAn.

2.1.1 Evaluating Responses to Volcanic Events

The focus and language researchers use to discuss catastrophes, especially volcanic events, have evolved as their framework for assessing the impacts to the hunter-gatherer groups have advanced over the last 50 years. In early studies of natural disasters there was an overall theme of terror, violence, panic, and disruption. As an example, "short term extensive volcanism is disastrous to terrestrial plants over vast areas, creating biological deserts or impoverished environments and causing significant difficulties for herbivorous mammals and the ultimate predator, man" (Workman 1979:345). While this could certainly be the case in some instances, it is proposed in a way that makes survival seem incredibly bleak and cultural and social systems completely inflexible. It can also be argued that, "a great deal of the literature examining the role of natural disasters in human history is sensationalist and based on unproven correlation" (Gratton and Torrence 2010:1). In more recent work, it has been shown that while ecological rebound could take time, the environment and people are highly resilient and are able to adapt to their 'new normal' and operate within those parameters. There has been a recent push in disaster studies to focus on the resulting innovation and resilience, instead of the possibility of vulnerability and collapse (Torrence 2016). Furthermore, some volcanic eruptions are stand-alone events and could be catastrophic for hunter-gatherers due to their inexperience with these types of events. Meanwhile groups experienced with high volcanic activity choose to live in those regions and have a desire to maintain their territory regardless of the hazards, preferring to rebuild after each eruption (Torrence 2016). We are able to model the possible effects of the WRAn, by understanding the range of environmental and anthropological responses to volcanic eruptions.

2.1.1.1 Environmental Responses

A wide range of vegetative effects are possible following the occurrence of a volcanic event. For example, after the 1912 Novarupta-Katmai eruption, the initial evaluation was bleak and disastrous for the future of the landscape on Kodiak Island (Griggs 1922). To Griggs' surprise, the ecological recovery of the region occurred much faster than expected, and two years following the event, it was noted that heavily impacted plants were showing signs of expedient recovery, particularly the grasses. Fieldwork following the Mount St. Helens eruption in 1980 has revealed "various combinations of depth, texture, and frequency of deposition produce a wide range of plant responses" (Antos et al. 2005:47). These studies reveal that even from one volcanic event, a wide range of environmental impacts can be expressed on the landscape, which is important to address when it comes to drawing comparisons and developing analogues. Each volcanic event is unique and varies in the size, scale, and season of eruption (presence or absence of snowpack), as well as the possible effects that the tephra imposes to both the proximal and distal ecosystems. Due to these factors, there are no perfect analogues for understanding the environmental responses to the WRAn tephra deposition in Yukon-Alaska in ~1625 cal BP; however, by studying the ecological responses from tephra deposition in an array of contexts it is possible to draw comparisons and model the potential environmental responses.

The Alaska Peninsula has been a focus of study for many years due to the high levels of volcanic activity throughout prehistory up to modern day. The Katmai eruption of 1912 and Aniakchak eruptions occurring between 4,400–3,600 cal BP have had particular attention and research conducted. This area is a particularly relevant analogy for this study, due to the similarity in flora and fauna that inhabit the area. Similarly, the Mount St. Helens eruption beginning in 1980 is also heavily drawn on for analogies for research purposes due to its recent date and intensive amount of ecological research that continues to be conducted even to this day (Swanson and Crisafulli 2018).

Regardless of the location or environment, it appears that vegetation survival is greatly impacted by the thickness of the tephra deposited on the landscape. Numerous studies have shown that as tephra beds increase in thickness, so do the range of plants negatively affected and the amount of time necessary for the landscape to regenerate (Griggs 1915; Grishin et al. 1996; Zobel and Antos 1997, 2018; Antos and Zobel 2005). On Kodiak Island, after the Katmai (Novarupta) eruption, most plant species that were buried and unable to penetrate the ~5–28 cm-thick tephra deposit either perished or laid dormant for multiple years (Griggs 1922), whereas woody plants, like willow, and others such as fireweed that could grow stolons (or runners) were the most successful post eruption (Griggs 1915, 1918). For example, within a year, some grasses, horsetail, and fireweed were able to colonize the tephra surface successfully. Areas that were occupied by spruce-dominated forest provided some amount of protection to the low-lying shrubs, herbs, and mosses (Griggs 1915). In addition, cracks in tephra beds created opportunities for plants to emerge in the years following the eruption, and sloped landscapes regenerated sooner due to tephra particles eroding downslope (Griggs 1918). Similarly, studies at Mount St. Helens have shown that some trees may survive burials over 2 m deep, while mosses and bryophytes can be killed by less than 5 cm; generally speaking, thin layers of a few millimeters are likely to have little effect on most flora (Antos and Zobel 2005).

A significant factor to consider is the succession of a forest after a tephra fall. When the vegetation returns, it will never grow back in exactly the same proportions prior to the eruption (Antos et al. 2005). This concept considers the landscape as a fluid, plastic entity rather than something that will or should be exactly replaced as it once was. On Kodiak Island, Griggs (1922) observed that plants were able to either lay dormant, waiting for erosion or weathering to allow them to emerge through the tephra, or were able to pierce through the tephra layer, sometimes creating two storied root systems. For a period of time after the Mount St. Helen’s eruption, there was a higher abundance of trees, particularly seedlings, with most shrubs and bryophytes experiencing temporary negative effects from tephra burial (Antos et al. 2005). This abundance of seedlings thrived because they were no longer competing for resources from the understory. Conversely, temporary physiological changes were experienced from deciduous trees located outside the main fallout area but there was no evidence of growth loss (Bilderback and Slone 1987), although some conifer species that lost their needles experienced reduction in tree diameter (Hinckley et al. 1984). Each individual plant response also contributes to the overall forest response and can impact the rate and composition of the resulting local ecology.

Close-interval pollen analysis was conducted on a geologic section exposed in sea cliffs approximately 42 km southeast of the Aniakchak caldera. Samples of peats and paleosols were analyzed at 2 and 5 cm intervals above the pyroclastic flow at 3,600 cal BP and 2 cm below. Samples below the tephra display a grass-dominated tundra with secondary sedge and minimal shrubs, possibly a product of a previously volcanically disturbed landscape (VanderHoek and Nelson 2010). Post-eruption, grass continued to be dominant; however, pollen concentrations were three to four orders of magnitude lower in the sediments than pre-eruption. Taxa that favor disturbed environments become more common, "implying unstable substrates with discontinuous vegetation" (VanderHoek and Nelson 2010:141). It was noted during that analysis that the pollen grains were abraded, implying aeolian transport with sharp mineral matter and that considerable increases of humic acids from decaying vegetation were present in the soils.

Depending on the location and soil composition, possibly a drier and/or nutrient-rich ecosystem could be created (Blackford et al. 2014). This is highly dependent on the landscape features and the volcanic event; however, during the Aniakchak II eruption of 3690–3610 cal BP a change in soils produced a switch from a Cyperaceae (sedge) dominated assemblage to a Poaceae (grass) dominated vegetation cover, suggesting modifications to the soil composition creating a drier and/or more nutrient rich ecosystem. Although this was located 1000 km from the source for the eruption, it exemplifies the possible range of modification that can occur due to tephra deposition.

Studies of ecological succession after the 1980 eruption of Mount St. Helens have demonstrated the pace of succession varied as a result of the survival, immigration, growth of organisms, and community development (Dale et al. 2005). In addition, different locations in the fall out zone experienced differing patterns or rates of succession based on previous species, distance from sources of propagules, amount of snowpack, or landscape structure (Allen and Huntley 2018). In areas of less than 30 cm of tephra deposition, linkages among plants, animals, and fungi established quickly and increased the rate of succession. Primary succession was largely reliant on interacting patch dynamics, and the establishment of plants, rodents, and fungi (either survivors or migrants), whereas secondary succession was more dependent on the tephra thickness and the underlying topography (Allen and Huntley 2018). Successional processes are less about time since eruption, but rather based on the emergence of patches of vegetation, the ability for plants and animals to thrive in these patches, and then expand; thus, a situation creating multiple trajectories of succession throughout the landscape. New habitats (including lakes, ponds, and creeks) were created in the disturbance zones (Dale and Crisafulli 2018), which significantly modified the predicted regional succession. The presence of snowpack has contradictory effects in the literature. Some studies argue it can make it more difficult for plants to thrive (Antos and Zobel 1992), while others suggest it offers a certain amount of protection from detrimental effects of the volcanic ash (VanderHoek and Nelson 2007).

Tephra effects on animals can range just as significantly as plants. Caribou have a difficult time recovering even from small amounts of tephra because of they graze on low-lying lichens and moss. The tephra that covered their food sources can cause increased tooth wear, inhalation of ash, and volcanic acid poisoning (Workman 1979; Riehle et al. 2000; VanderHoek and Nelson 2010). This was directly witnessed after a minor eruption of Aniakchak in 1931 where caribou in the region abraded their teeth almost to the point of starvation, and many newborn calves were lost as the herd migrated away from the fallout area (Trowbridge 1976). In addition, caribou in Katmai were observed as experiencing negative effects from 2.5–10 cm of ash (Jagger 1945), and in Iceland after the Hekla eruption as little as 1.9 cm of ash cause detrimental effects to reindeer (Malde 1964). The White River tephra (the eastern lobe) deposition, in conjunction with the Medieval Warming Period, has also been attributed to a partial genetic replacement event of caribou located in the Southern Lakes region of the Yukon ~930 cal BP (~1000 BP) (Kuhn et al. 2010). This genetic information, coupled with a lack of caribou remains preserved in regional ice patches between 1330-940 cal BP (Farnell et al. 2004), provides evidence that caribou would have been highly affected by tephra in the area. This is in contrast to moose, which may not have experienced abraded teeth or starvation because the shrubs on which they browse could be quickly cleared of tephra by wind and rain (Riehle et al. 2000). On the other hand, moose would likely still be negatively affected by the ingestion of toxic chemicals (VanderHoek and Nelson 2007), and contamination of vegetation within ponds in which they feed (Workman 1979). Limited studies have been conducted on small mammal populations in volcanic zones. After the Mount St. Helens eruption in 1980, it was noted that burrowing animals saw a surprisingly high rate of survival (MacMahon et al. 1989) and, thanks to scattered refugia, they were able to persist along with an assortment of migrant species that eventually inundated the landscape (Crisafulli et al. 2005). Mammal succession after a volcanic eruption is important to consider, as some species are sensitive to change while others act as architects for the environment by modifying the landscape through their trampling and digging, as well as spreading seeds, fungi, and plants (Crisafulli et al. 2005). Small mammals, particularly those that burrow, can escape the initial negative impacts of tephra disposition and thrive in the succeeding years. Crisafulli et al. (2005) were surprised that mice, squirrels, voles, shrews, gophers, and chipmunks at Mount St. Helens survived in many locations within the affected landscape and were also able to colonize highly disturbed regions soon after.

The early summer eruption of Katmai proved to be disastrous to the salmon population because of the high ash load in the rivers, preventing many of the species from entering the rivers to spawn, inhibiting the growth of fry (Riehle et al. 2000). For the following two years, salmon spawning numbers returned to normal; however, between 1915 and 1920 commercial salmon catch declined by about 50% for the next 5 years before recovering completely (Dumond 1979; VanderHoek 2010). It has been noted that the effects on salmon can vary based on the specific species due to their varied life cycles, spawning ages, and preferred locations to spawn (Riehle et al. 2000). Fish recovery and spawning will also be greatly affected by the amount of tephra deposited into the streams, the season of deposition, and flow rate of the water. If tephra can be cleared out of the streams before spawning or if rivers have refuge areas, fish resources could potentially survive with limited adverse effects.

In summary, tephra deposition from volcanic events can have profound influences on the plants and animals in the surrounding region. The ability for the local plant and animal resources to regenerate relies greatly on the thickness of the ash bed, the individual qualities of the resource, the season of deposition, and the surrounding landscape. Some plants and animals are able to rebound quickly with limited damaging effects acknowledged, whereas others could be completely obliterated with migratory influence necessary in order to regenerate the area. This range of effects on environmental resources displays the complexity in which tephra deposition can alter the landscape.

2.1.1.2 Cultural Responses

Volcanic eruptions in the archaeological and historic records had the potential to cause a wide range of concerns for human populations living nearby. Anthropological studies have provided insight into the range of variables that are present between volcanological-human interactions. One variable that impacts human responses is the level of mobility and social organization of the group. Sheets (2001) concluded that there were two main variables driving the responses of the groups studied in Middle America (El Salvador, Panama and Costa Rica): the nature of the tephra (thickness, composition, climactic changes, and aerial extent of the fall-out), and socio-cultural factors (competition for resources, residential mobility or sedentism, adaptation and economy of society, density and distribution of population, political system, and reliance on fixed facilities). Sheets (2001:73) determined overall that "simple egalitarian societies apparently were more resilient to sudden massive stress, in the long run, than were the more complex chiefdoms or states". It appears that low population density and lack of a built environment allow for greater flexibility on the landscape than a built environment with integrated economies and political systems. This study is helpful to frame catastrophe studies as it shows the variability of human response can be based not just on the on the local environment, but also the flexibility of the social structure.

While it could be the case that explosive, overwhelming events could appear to produce negligible effects to the landscape in one instance, it is also possible that these events could produce differing results depending on a number of other factors, including time of year or stability of the culture occupying the region. Archaeological work in the Aniakchak region has recorded over the 10,000 years of volcanic activity that occurred in prehistory, with only a few that could be attributed to contributing to cultural shifts within the populations (Dumond 2004; 2011). Post-eruption human reoccupation in this region appears to favour coastal regions returning within 150 years, whereas inland regions were left uninhabited for up to 1500 years (Barton et al. 2018). In the Alaska Peninsula, the resilience of some resources and the people that continued to harvest them provides an analogy for other regions and their potential effects on ecological resources. For example, following the 1912 Katmai eruption people began to return almost immediately afterwards for resource gathering and then resettled completely as early as two years later (Dumond 1979). A shift in settlement patterns and subsistence strategies may be temporarily necessary after an eruptive event; however, it may not be required over the long-term. Temporary relocations could intensify trade relationships, create opportunities for information sharing, and provide opportunities to strengthen social bonds. This provides an example of how a wide diet breadth and connections to nearby populations are necessary in order to adapt to changing environmental conditions.

The Kuril Islands are a case study in disaster research not only because of the high occurrence of volcanic eruptions over the years, but also the high probability of landslides, earthquakes, tsunamis, and climatic changes. This has provided an opportunity to study prehistoric hunter-gatherer groups' vulnerability to the highly dynamic environment in the context of relative isolation. Fitzhugh (2012) concludes that while volcanic activity may have caused some negative effects on the landscape, it was also possible that these volcanic events actually assisted the mostly maritime hunters by increasing sea life productivity, and that there was no evidence that people modified subsistence strategies to minimize risks of natural disasters. It is interesting to note that preferential settlement locations were identified in regions that would have been protected from tsunamis (Fitzhugh 2012). This could show either a sampling bias, or a mitigation strategy used in order to protect their shelters. The authors also concluded that despite the frequent occurrence of these events over time, there was no evidence of population decline and they theorize that this resilience was in part due to the dependence of social networks between the islands and the ability to temporarily relocate to safety if necessary (Fitzhugh et al. 2016).

Recent work in the middle Susitna River Valley (mSRV) is particularly relevant as the most recent eruption, the Devil tephra from the Hayes vent, which occurred between 1625–1825 cal BP (Mulliken 2016), is rather close to the recently revised date of the WRAn between 1560–1689 cal BP (Reuther et al. 2019). Considering the volcanic vents of these two eruptions are ~570 km apart, this could have created a much larger impact on the ecology of interior Alaska if the events occurred in close succession. Analysis of the possible responses to the Devil tephra concluded that since it was only 3–5 cm thick where it was preserved, and environmental recovery could have been within a few years. Archaeologically, this time period is characterized by high residential mobility and broad-based subsistence patterns (Potter 2008a), making it likely that hunter-gathers were able to re-locate to more productive resource areas. Archaeological material in the area, in the form of the characteristic Northern Archaic notched points, suggest that reoccupation occurred soon after. However, the earliest radiocarbon date post-Devil tephra is

1380–1520 cal BP, possibly indicating a much longer abandonment of the region (Mulliken 2016), or inadequate sites with radiocarbon dates in the region. Additionally, the Watana tephras occurred between 3360–4400 cal BP in the mSRV with the first cultural component following that tephra occurs 2160–2330 cal BP signally a much longer abandonment of the region due to ecological instability. While no sites located between the Watana and Devil tephras contain notched points, they do contain a variety of medium and large mammals, including caribou (Mulliken 2016), indicating that the mSRV continued to be an important resource acquisition site even after a period of extended ecological recovery.

The pace of ecological succession and cultural reoccupation following the WRAn along the Yukon-Alaska border likely varied depending on the season of the eruption, the distribution and thickness of the tephra, and where humans were on the landscape during the eruption. Studies on the affects of this event is limited within the field of hunter-gatherer populations. While oral traditions document that northern Dene/Athabascans recall an eruption in the White River basin (Moodie et al. 1992), it is unclear if this is in relation to the Eastern lobe exclusively, or possibly the Northern lobe as well. It is often speculated that it was the WRAe volcanic eruption caused population displacements, technological changes, language differentiation, and migration of the Dene/Athabascan people to more southern and eastern locations (Workman 1974, Derry 1975; Workman1979; Moodie et al. 1992; Hare et al. 2004); however, it has been more recently critiqued as being "not as catastrophic as most people believe" (Gordon 2012:91). Ecological discontinuity does not necessarily equate to cultural change in the same area, as multiple sites in the region, including Little John (Easton 2014), Tatlmain Lake (Thomas 2003), and Luu Cho (Greer 1983) provide evidence for consistency of lithics and site use below and above ash falls. Gordon (2012) proposed that the change in game availability is what promoted technological changes over time, since these transitions are broadly comparable to cultural historical changes elsewhere in North America (Hare et al. 2004). Further investigation into the WRAn can provide fruitful research into the effects that volcanic events had in the region during the Late Holocene.

2.1.1.3 Ecological Expectations Following the WRAn

Field research in the WRAn eruption impact area established that the tephra deposit ranges in thickness from a few millimeters to up to a meter in the stratigraphic record (Preece et al. 2014). Due to this variability, erosion, and unknown amount of compaction, it is difficult to make an adequate prediction of the expected effects on vegetation, save a few broad conclusions. It has been previously stated that vegetation such as low-lying mosses and lichen were the most negatively affected once covered (Antos and Zobel 2005). While minimal tephra would only affect the smallest low laying taxa, a tephra <15 cm thick would begin to negatively impact larger taxa such as trees (Zobel and Antos 2018). Generally speaking, the smaller the species, the greater the impact tephra deposition would inflict on the plant's recovery (Table 2.1). Therefore, it is likely that for a short period of time, trees and shrubs would be dominant on the landscape and it would take some time for mosses, herbs, and grasses to re-emerge through the tephra. On the other hand, depending on the thickness of the tephra, species that are capable of penetrating through, such as horsetail, fireweed, and grasses, could have flourished as early as two years post-eruption (Griggs 1915, 1918). An established sub-arctic boreal forest environment dominated at the time of the WRAn eruption; it is possible that for a short period of time, say 5–10 years, following the eruption animals and plant life were temporarily negatively affected but were able to rebound gradually starting from the areas with the thinnest tephra.

Table 2.1 Impact of tephra thickness on plants at Mount St. Helens (adapted from Zobel and Antos 2018).

Tephra Thickness	Significant Impacts to Plant Species	Plant Recovery (20-30 yrs post-ash)
0–5 cm	Bryophytes and mosses	Reduced but slowly rebounded
5–10 cm	Shrubs with snowcover	Recovered more slowly
10–15 cm	Mosses eliminated Shrubs and herbs reduced	Highly dependent on snowpack
15 cm +	Tree suffered some damage Other species eliminated	Influenced more highly by colonizing species

At the Forty Mile and 6-Mile Lake study locations, the buried tephra is approximately 1 cm thick (Thomas 2004; Bigelow 2014). However, the original tephra thickness might have been greater or lesser as experimental research suggests that compaction, slope angle, vegetation, faunal activity, and geomorphic environments can both increase and decrease the amount of tephra preserved in the record (Blong et al. 2017). The tephra preserved stratigraphically is not the same that was visible on the landscape at the time of deposition. For example, the town of Kodiak is located ~170 km from the volcanic vent and, in 1912, the tephra fall was recorded between 250–600 mm over a period of 60 hours. Observations made 66 years later indicated an average of 150–210 mm in areas without significant erosion or redeposition (Blong et al. 2017). In addition, depending on the predominant vegetation and faunal activity in the region, tephra thickness can be altered significantly enough to be virtually absent in only a few years. Therefore, it is necessary to consider that even though the WRAn tephra is recorded as 1 cm thick, its thickness at deposition could have been greater when it fell.

In order to assess the time and structure of environmental rebound after a disturbance, such as the WRAn, it is worthwhile to address the concept of ecological succession. The objective of successional ecology is to identify the similarities and differences in the processes and patterns of natural systems after a disturbance, in order to make generalizations and identify the basis for differences (McCook 1994). While environmental recovery is unique based on the initial conditions, season of occurrence, presence/absence of snowpack, vegetation composition, and type of disturbance, there can be commonalities and general trends acknowledged. Certain species may thrive in disturbed landscapes such as fireweed (*Chamerion angustifolium*) and dragonhead (*Dracocephalum parviflorum)* (Government of Yukon 2019), whereas others may be obliterated or take extensive periods of time to recover such as lichens (Griggs 1918; Collins et al. 2011).

It is necessary to consider the frequency and severity of ecosystem disturbances when discussing successional patterns necessary to regenerate the landscape. The severity of disturbance and biotic affects occurs on a continuum; in effect the larger the disruption the greater the impact will be on the ecosystem (McCook 1994). Studies in northern boreal forests provide insight into what could be expected in vegetation regeneration following a large-scale infrequent ecosystem disturbance, such as the WRAn. Following a forest fire, the initial colonizers include grasses, forbs, sedges, some non-vascular plants and shrubs. Over time deciduous and coniferous trees become established and provide shade and a canopy for a wider range of taxa (Oswald and Brown 1990; Nelson et al. 2008). Disturbances can also provide the opportunity for biodiversity and rejuvenation of mature forest stands creating diverse patches and increased landscape heterogeneity (Nelson et al. 2008). While initially detrimental for animals and people, this could provide the possibility for greater resource procurement in the future.

Animal responses to a tephra fall in the study region would likely mirror negative impacts to the vegetation, given their dependence on particular plant resources. The Forty Mile Site was ethnographically known as a fish camp where whitefish and salmon were obtained, and as a caribou intercept point (Mishler and Simeone 2004). Migratory caribou are reliant on lichen and would have been affected even in areas with very small ash falls. Fish experience effects in slow moving streams or when thick tephra falls clog up rivers. Moose being browsers, would not be impacted by thin tephra falls and only experience negative affects after 10–15 cm when shrubs began to struggle and could potentially become a targeted resource if caribou were no longer available. Small mammals show that they are able to withstand thicker tephra falls due to their ability to hide from the initial event, and could also become a targeted resource in the study area as diet breadth increases.

2.2 Human Behavioural Ecology

A major theme in disaster research has been adaptability and resilience. Human populations, regardless of the time period, have displayed that they are capable of prospering in a wide range of environmental conditions, either natural or constructed. In anthropology, "adaptation has been and continues to be a central concept in understanding the human use of the physical environment… strategies of a sociocultural nature adopted by individuals and groups to cope with the conditions presented by the physical and cultural environments in a way that enables them to survive and/or prosper" (Oliver-Smith 1999:25). In archaeology, the study of human adaptability can be framed using HBE frameworks because it forms predictions and focuses on the interaction between people and the environment. In addition, it "studies the fitness-related behavioral trade-offs that organisms face in particular environments. Behavioral ecology asks why certain patterns of behavior have emerged and continue to persist and looks to their socioecological context in seeking answers" (Bird and O'Connell 2006:144). By considering all aspects of human behavioural patterns, we are more equipped to understand the impact and manifestation of that adaptation, and thus the effects these catastrophes had on people. In many ways, each catastrophic event could be seen as having special or unique consequences to the people in the fall-out area; however, within the field of disaster research (regardless of the focus on prehistoric or historic, or present day events) it can be realized that patterns of behaviour do exist.

HBE aims to apply evolutionary ecology concepts and models to the study of human behaviour. This is achieved primarily through the use of models that assist in generating predictions and testing hypotheses. This approach is "self-consciously reductionist. It relies on very simple models that focus their analytical gaze one-at-a-time on quite specific elements of the foraging economy" (Winterhalder 2001:14). Optimality models are created with a set of basic assumptions; the fitness related goal of the behaviour, a decision variable or strategy associated with achieving that goal, trade-offs connected with the decision, the currency(s) in which to evaluate trade-offs, and constraints that define or limit the situational response (Kelly 2000: Bird and O'Connell 2006). The reason many archaeologists use this theoretical framework, and the models associated with it is its focus on behavioural questions, it is integrative, and it provides a structure for testing hypotheses. These models are not directly tested in this research; however, will assist in providing expectations about human decision–making processes regarding interactions with the landscape and food resources.

The diet breadth model assumes the goal of foraging is to optimize nutrient acquisition while minimizing energy/time expenditure. It assumes that hunter-gathers have a rank-order of most desirable resources based on this goal and that top prey will be taken as encountered and lower ranked will be added in descending order. Efficiency is maximized when the nutrient value of the item outweighs the search and processing requirements; therefore, diet breadth will shrink if high ranking prey become more abundant and will expand as high ranking prey become more scarce (Bird and O'Connell 2006). This model can be helpful to determine aspects of archaeological cultures and the decisions they are making in terms of resources. While generally the diet breadth model is helpful in gathering insights into how hunter-gathers made food choices it is important to note that, "there may be a time lag between environmental change and behavioral change" (Kelly 2000:66). This could potentially bias the model results, especially when attempting to apply diet breadth to areas that have recently undergone a natural disaster. As is often the case, the results are only as good as the constructed model, or the questions being asked of it. Especially when considering that food is not the sole reason for hunting animals, acquisition of fur, sinew, bone, and antler for an array of uses should also be noted. In addition, due to the limiting nature of these optimal foraging models it is sometimes necessary to further interpret the results, and those interpretations have the possibility to contain bias. For example, individual groups might prefer specific resources based on taste, taboos, or season.

Diet breadth could potentially be used in a number of ways to analyze the effects of the WRAn. A change in diet breadth could reflect the potential environmental effects that impacted the desired prey and the landscape. In addition, it could be possible to look at what vegetation resources were affected and if they corresponded to the reflected diet breadth or a change in ranked species selection of the people. For example, if the WRAn volcanic event covered the landscape with ~1 cm of tephra, this would negatively affect vegetation such as mosses and lichens. This would then in turn be reflected in a decreased in the subsistence use of caribou and small game populations, but most likely not a decline in the use of moose or fish populations. When determining changes in diet breadth of the site, these would be important factors to note due to the fact that the limited diet breadth demonstrated could potentially be due to the effects of the volcanic eruption and not ranking of the prey. Accurately assessing diet breadth does require a robust faunal data set in order to interpret the food choices of past cultures.

Similar to prey choice models, patch choice models emphasize mean rate maximization and have similar constraints, yet they differ in the assumptions about distribution and net energy gain as a function of handling time (Smith and Winterhalder 1992; Bettinger et al. 2015). A patch has been defined as a cluster of resources which hunter-gatherers are able to perceive and utilize in order to maximize their resource acquisition. Hunter-gatherers choose patches based on known resources of relatively high abundance. "Within a patch, the rate at which food can be harvested declines as a function of the time the forager spends there" (Winterhalder 2001:17). This type of modeling can be useful to assess the productivity of an area and predict the prey abundance in an area. Generally, resource patches are abandoned before they become completely stripped of resources so that they can regenerate to be used again in the future.

Another model that could provide insight into resource patch selection is territorial defense. These models look at the energetic costs associated with defending resource patches and their benefits. One of the major considerations in determining energetic costs of resource defense is density of resource distribution (Broughton and O'Connell 1999). These types of modeling patches could provide insight into catastrophic events because there could be increased areas of low productivity following a natural disaster and it would be necessary for hunter-gatherers to make decisions based on larger groupings of resources and decide on length of time to spend in a patch before moving on to another. In addition, if a higher population of people were clustered around patches it may be necessary to model the appropriateness of defense costs due to increased carrying capacity and potential stress on resources.

Mobility is another key concept in HBE; how hunter-gatherers move across the landscape is key to their interaction with the landscape's resources. The mobility strategies defined by Binford (1980) are the most commonly referenced. He characterized the difference between logistical and residential mobility and suggested that hunter-gatherer groups could be described in terms of the degree they displayed these patterns. Residential mobility was defined as the movement of all group members from one locality to another based on resource abundance within the patch. Logistical mobility was defined as speciality task groups partaking in temporary excursions from the residential base to acquire specific resources. These definitions have persisted and are commonly used to describe mobility patterns in both cultural anthropology and archaeology. Binford (1990) later went a step further and discussed how these mobility patterns coupled with the environmental conditions could affect housing needs and their construction and transportability. These concepts have persisted within the field and have been further developed to expand their use and make them assessable for comparative analysis (Kelly 1983).

All of these definitions of mobility are in a large part drawn from the resources available to the hunter-gathers in their current location. The range between collector and forager, residential and logistical mobility strategies depend largely on a location where resources are known and, for the most part, predictable. "Mobility is one method that hunter–gatherers use to reduce risk by taking advantage of the spatial and temporal structure of resources, essentially allowing them to move away from scarcity" (Smith 2003:62). The ability to make planned moves and relocate to areas with higher resource potential is critical for the success of hunter-gathers. However, limited focus has been given or considered for unpredictable environments and the necessity to move into a potentially unknown landscape. When disasters occur, especially ones where long-term resource depletion occurs, the necessity to move could completely disrupt cultural systems.

In a differing perspective when addressing the topic of mobility, Morgan (2009:394) states, "It is conceivable that climate change and variability favour not economic maximizing or even efficiency but economic security. Security, of course, comes with its own costs and rewards, but is clearly unlike the optimizing behaviours associated with the evolution of complex hunter–gatherer, agricultural, and industrial economies during the Holocene." This could potentially affect mobility, population size, resource use, or settlement patterns. It could be that when various choices are presented, groups engage in activities that would lower risk and uncertainty (Pike-Tay and Cosgrove 2002). When events occurred that forced a change of resource availability or landscape knowledge, people would react in a logical and systematic manner in order to maximize their success and produce the most profitable outcome. This could involve combining and/or adapting mobility strategies, finding refuge in other territories, or joining with other groups temporarily. This could be visible in the archaeological record by increased site density in sites in the surrounding area, or an influx of exotic resources after returning to the previously effected area.

Resource scheduling involves organizing mobility patterns to coincide with the seasonality and distribution of available resources to ensure efficient harvesting. Moves from one location to the next were scheduled to coincide with the optimal resource gathering at specific times of the year (Smith 2003). At times, it would be necessary for hunter-gatherers to monitor regions in order to determine when and where resources were abundant in order to take advantage at peak intervals (Kelly 1983). This framework also involves a great deal of flexibility within the group, because there is inherent variation in resource scheduling and it would be necessary to have alternative strategies if resources were under performing (Pike-Tay and Cosgrove 2002). This theory is useful in assessing responses to the WRAn due to the fact that natural disasters can modify the predictable landscape and cause a normally abundant resource to underperform. It would be necessary to monitor patches and determine when movement would be most ideal and cope with variation of resources. It could also be that a shift in resource scheduling or prolonged site use would be necessary in order to ensure efficient use of the landscape.

The HBE models of diet breadth, patch choice, territorial defense, mobility, and resource scheduling consider the behaviour and decision-making processes of hunter-gatherer people and are useful when studying the effects of those living in a volcanically impacted region. While this study does not explicitly test each of these models, it considers the archaeological and palynological results alongside the human behaviour predicted in an attempt to further understand the choices people made within a landscape affected by the WRAn. These models may provide further insight for the human responses to the environmental changes caused by the tephra deposition. The pollen analysis will provide context for determining the effects of the WRAn on the landscape, which will help to frame the models and consider the potential behavioural responses of the individuals.

Chapter 3: Background of the Study Area

The study area incorporates regions directly impacted by the White River Ash northern (WRAn) lobe eruption in eastern interior Alaska and the Yukon. The area in question extends between Mount Churchill to the south and ~200 km beyond the community of Eagle, Alaska, to the north. Pelly Crossing, Yukon, defines the eastern boundary; the Alaska community of Tanacross marks the western edge. The research focus is within the central distribution of tephra fall (Figure 3.1) as mapped by Mulliken et al. (2018).

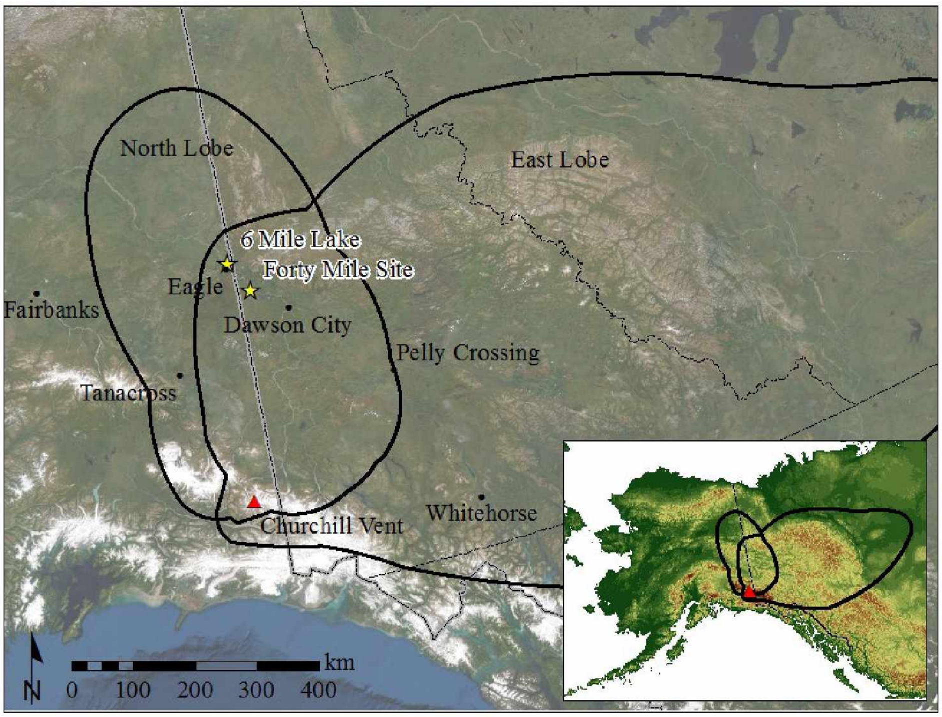


Figure 3.1 Map of study area and locations. Location of Churchill Vent, and distribution of tephras for the WRA northern and eastern lobes (distributional data from Mulliken et al. 2018).

Before further discussing the background for the study area, it must be acknowledged that each country has unique systems and typologies for characterizing environmental, geological, geographical, ecological, and climactic regions. In the past, the majority of these classification systems and descriptions ended at their respective borders. This presents issues when working on transnational projects if typological sequences do not blend or associate with one another. For this reason, classification systems that extend across borders have been chosen when at all possible, and subsequently using the additional systems as supporting data.

This chapter introduces the background information relevant to the research and is divided into three sections. Section 3.1 describes the regional environment including the geography, climate, ecology and volcanism. Section 3.2 outlines the culture history of the region detailing the ethnographic context, territory, and archaeological background. Section 3.3 presents the study locations and background information pertaining to the Forty Mile Site and 6-Mile Lake.

3.1 REGIONAL ENVIRONMENT

3.1.1 GEOGRAPHY

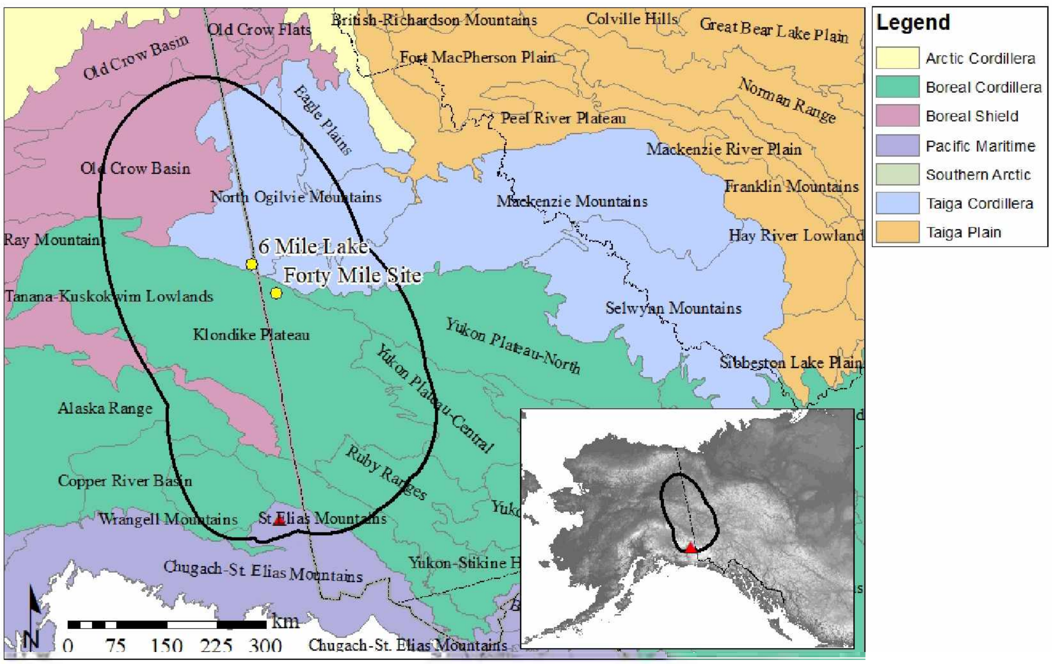


Figure 3.2. Ecoregions map of the study area, as defined by Smith et al. (2004).

The study area is located within a number of ecoregions. However, the predominant one is the Klondike Plateau as defined by Smith et al. (2004), and thus will be the focus of this overview (Figure 3.2). Characteristic features of the Klondike Plateau include smooth-topped ridges dissected by deep narrow valleys. This region was not glaciated in the recent past (last 3 million years); therefore, long periods of weathering have resulted in extensive upland boulder fields (Smith et al. 2004; Gallant et al. 1995). Permafrost in the region is discontinuous but widespread, and is typically present in valley-bottoms and upland soils but absent in well-drained slopes. The study area is located within the Yukon River watershed, which begins in the lakes and streams in British Columbia, extends throughout the Yukon Territory, and traverses the expanse of Alaska to eventually drain into the Bering Sea (Smith et al. 2004).

3.1.2 Climate

The Klondike Plateau climate is continental with dynamic shifts between warm summers and very cold winters. Annual mean temperatures are near -5°C, with January being the coldest at a mean of -23 to -32°C and July being the warmest from 10 to 15°C (Smith et al. 2004). While frost can occur year-round, it is least likely in July. Precipitation ranges from 30–50 cm annually with a gradual increase from the southeast to the northwest (Smith et al. 2004). The wet season occurs from June to August with a monthly mean of 5–9 cm of rainfall, while the lowest precipitation occurs from February to April with 1–2 cm (Smith et al. 2004). Lakes and waterways start to freeze up in late October and stay frozen until mid-May with freeze-up and break-up generally taking two to three weeks to complete (Ager 1975; Hosley 1981). The amount of sunlight per day ranges in the area based on precise latitude. As an example, Dawson City in Yukon, receives approximately 4 hours of sunlight on the winter solstice, and approximately 21 hours of sunlight on the summer solstice (NOAA 2005; Government of Canada 2012). These shifts in amount of sunlight greatly affect what is possible on the landscape for people, animals, and plants at different times of the year.

3.1.3 Ecology

Vegetation in the area ranges from boreal forest in the valleys and on low slopes, to alpine tundra on ridge crests, with the tree line occurring between 1,000–1,200 meters above sea level (masl) (Smith et al. 2004). Black spruce (*Picea mariana*) and white spruce (*Picea glauca*) forests are the dominant in the region, occurring in either pure or mixed stands with balsam poplar (*Populus balsamifera*), paper birch (*Betula* spp.), and trembling aspen (*Populus tremuloides*) (Smith et al. 2004; Gallant et al. 1995). The shrub layer is dominated by shrub birch (*Betula glandulosa*), willow (*Salix* spp.), alder (*Alnus* spp.), Labrador tea (*Ledum palustre* spp.), alpine blueberry (*Vaccinium uliginosum*), prickly rose (*Rosa acicularis*), and a number of other ericaceous ground shrubs that overlay feathermosses, diverse forbs, and foliose lichens (Smith et al. 2004; Gallant et al. 1995). Wildfires are common, given the area's high frequency of lightning strikes, and can greatly influence composition and maturity of the forest (Gallant et al. 1995).

Wildlife in this region was historically one of the most biologically varied and abundant within the Boreal Cordillera (Smith et al. 2004) and has provided a wide variety resources for Indigenous groups to thrive including large and small game, salmon, freshwater fish, edible and medicinal plants (Gallant et al. 1995). Large numbers of caribou (*Rangifer tarandus*) from the

Fortymile, Nelchina, Klaza, Aishihik, Chisana, and Mentasta herds all enter this area at some point during their seasonal migrations (Smith et al. 2004). Other mammals include moose (*Alces alces*), Dall sheep (*Ovis dalli*), black bear (*Ursus americanus*), grizzly bear (*Ursus arctos horribilis*), lynx (*Lynx Canadensis*), grey wolf (*Canis lupus*), coyote (*Canis latrans*), red fox (*Vulpes vulpes*), wolverine (*Gulo gulo*), snowshoe hare (*Lepus americanus*), beaver (*Castor canadensis*), marten (*Martes americana*), porcupine (*Erethizon epixanthum*), muskrat (*Ondatra zibethicus*), and a number of other small mammals (Chester 2016; Smith et al. 2004). The region is host to a variety of spring and fall migrations of swans, geese, ducks, and shorebirds, used by various raptor species, a year-round population of grouse (*Falcipennis* spp.), ptarmigan (*Lagopus* spp.), three-toed woodpecker (*Picoides dorsalis*), grey jay (*Perisoreus Canadensis*), raven (*Corvus corax*), chickadee (*Poecile* spp.), and other minor species of birds (Smith et al. 2004). Fish varieties are also expansive and comprised of both anadromous and non-anadromous species. Including but not limited to: Chinook (*Oncorhynchus tshawytscha*), Chum (*Oncorhynchus keta*), and Coho (*Oncorhynchus kisutch*), Dolly Varden (*Salvelinus malma*), whitefish (*Prosopium* spp.), arctic grayling (*Thymallus arcticus*), northern pike (*Esox Lucius*), and burbot (*Lota lota*) (Smith et al. 2004; Haynes and Simeone 2007).

3.1.4 Volcanism

Volcanic events are represented in the geological record by the presence of tephra beds, which can be viewed stratigraphically. Tephra consists of a wide range of explosive volcanic products, including cinder and ash, which are expelled during an eruptive event. Tephra can vary in particle weight and size and, therefore, can travel through the air for various distances before being deposited on the landscape creating a pattern based on the volcano origin, energy, and specific wind direction and speed (Sarna-Wojcicki 2000). Yukon-Alaska has been subject to a number of volcanic eruptions in the past. These events range from small-scale localized events to extensive widespread occurrences (Davies et al. 2016) that had the ability to cause a great deal of environmental modification. A range of these eruptions and their effects have been previously discussed Chapter 2.

3.1.4.1 White River Ash

The dual volcanic eruptions that occurred in the Mount Bona-Churchill vicinity have been termed the White River Ash due to their initial recordings and observations in the White River basin by Frederick Schwatka (1885). Although initially theorized to be a single eruptive event, further research demarcated two independent eruptions that occurred approximately 400 years apart. These events have been termed White River Ash eastern lobe (WRAe) and northern lobe (WRAn) and have been categorized as plinian-type eruptions. Plinian eruptions have been defined as explosive events that ejected a steady stream of magma and gas released at high velocity from a vent (Wilson 1976). The tephra layer dispersed during these types of volcanic events cover at least 1000 km^2 inside the 0.01 maximum thickness isopach (Walker 1973).

The WRAe has been dated to ~1147 cal BP (Clague et al. 1995). The total volume of the tephra expelled during this event has been calculated to be ~47 km^3, the cloud it produced is theorized to be 40–45 km in height, and it is believed to be the result of the largest Holocene plinian eruption known (Lerbekmo 2008). The resulting tephra layer extends from the volcanic summit in Alaska to the edges of the Great Slave Lake in Northwest Territories, and particles of it have even been identified in ice cores in Greenland and peat records in Ireland (Jensen et al. 2014). The WRAe is theorized to have left a lasting impact on the nearby populations by creating a less ecologically stable area of land resulting in relocation, language differentiation, and technological adaptations (Workman 1974, 1979; Derry 1975; Moodie et al. 1992; Hare et al. 2004). An eruption in the White River basin has limited documentation in the oral traditions of the northern Dene/Athabascans (Moodie et al. 1992). It is often speculated that it was one or both of the WRA volcanic eruptions which caused population displacements and migration of the Dene/Athabascan people to more southern locations (Moodie et al. 1992; Mullen 2012). While a southern migration has also been broadly identified in the linguistic record we don't know the duration or specific effects of the tephra fall (Derry 1975, Workman 1979).

The date of the WRAn event was recently reanalyzed to 1625 cal B.P. (Reuther et al. 2019). This northern lobe eruption has seen significantly less investigation than the eastern lobe, due to its smaller size and less accessibility to study sites located within the fall out area. The estimated volume of this lobe was only 10–20 km^3 (Bostock 1952; Berger 1960). An analysis conducted on the soils located in the overlapping zone of the two tephra falls (Smith et al. 1999) indicates that 5–10 cm of WRAn tephra was deposited after which ~20 cm of regenerated forest floor developed, which it was buried by a 60 cm layer of ashy-pumiceous tephra from the WRAe. This provides an example of the differing thickness of the plumes between the two events. Limited research has been conducted to date on the cultural impacts of the less geologically destructive WRAn at the Yukon-Alaska border.

A major factor in determining the level of impact tephra deposition has on the local vegetation is the season of the volcanic eruption, (Zobel and Antos 1997; Hotes et al. 2004; Payne and Blackford 2008; Waythomas 2015; Mulliken 2016; Zobel and Antos 2018, and more), including the presence or absence of snowpack. Multiple studies have attempted to determine this for the both the WRAn and the WRAe using factors such as high elevation atmospheric wind patterns, and geographic features (Hanson 1965; West and Donaldson 2002), and lacustrine deposits in lakes (MacIntosh 1997) with opposing outcomes. Based on predominant wind patterns it is suggested that the WRAn was deposited in the summer and the WRAe was deposited in the winter (Hanson 1965; West and Donaldson 2002). However, it has been noted that depending on the climactic data used, this could be reversed (Wahl et al. 1987). MacIntosh (1997:27) concluded that seasonal wind direction was variable enough to "not be considered an accurate predictor of seasonality" especially when projecting over a thousand years into the past. Instead, he analyzed the character of tephra stratigraphy from lacustrine deposits and concluded that the WRAe likely erupted between May and October based on multiple lakes, and a preliminary conclusion based on one lake that the WRAn occurred in the winter.

Mullen's (2012) model demonstrated that the WRAn affected the Dene/Athabascan population, causing a temporary relocation or at least an increase in archaeological sites surrounding the affected area. To test the effects the WRAn and WRAe had on Dene/Athabascan speakers, Mullen (2012) used radiocarbon dates of sites as a proxy for population size. He digitized the extent of the two volcanic events and the ages of sites located in Alaska, Yukon, NWT, and British Columbia, and their presence of Wiki Peak sourced obsidian artifacts. The model concludes that the data generally supported the hypothesis that both Mount Churchill eruptions caused migrations from the affected areas. This exploratory study is significant in independently modeling the two eruptions, although the author warns that the results are tentative due to a limited sample size. Based on the site information available at the time, Mullen (2012) argued that people emigrated from the affected land; however, the full consequences of the event on local cultures are unknown.

Recent archaeological investigations in the Tanana region provide preliminary insights into the effects of the WRAn on human populations. A 2011 survey conducted by Lynch et al. (2018) recorded eight new archaeological sites located south of Northway Junction by the Nabesna and

Chisana Rivers with 5–30 cm WRAn tephra. It was concluded that prior to the eruption a larger, richer lithic assemblage was present, with only side-notched points recovered. These differences were attributed to the transition between Northern Archaic to Athabascan periods that correlate coarsely with the WRAn deposition (Potter 2008b; Lynch et al. 2018). It is important to recognize these broad scale cultural transitions in connection with the site-specific data. This broad scale change could already have been in motion and was triggered by these large-scale events, or perhaps events such as the WRAn created the opportunity for increased rates of interaction between hunter-gatherers leading to cultural exchanges to be disseminated more rapidly, accelerating the rate of change that was already occurring. At one newly recorded site (Jatahund Lake–1, NAB–0483) artifacts and dates suggest an immediate reoccupation of the site (Lynch et al. 2018); however, these results are taken with caution, as the charcoal sample was acquired from a test pit with limited spatial sampling, not an excavated cultural feature. Newly discovered sites in the study region are important as they could have been be occupied by the same hunter-gatherer groups and experienced similar effects from tephra deposition.

3.2 Regional Culture History

3.2.1 Ethnographic Context

Since the project area is located half within Alaska and half within the Yukon Territory there are some unique circumstances that are presented when conducting an ethnographic overview. Due to the evolution of the settlement and land claim agreements Indigenous groups in this region have had to identify "traditional territories" in order to work within the framework of modern governmental controls (Easton 2001). While these modern traditional territories have been identified and outlined on modern maps and are referenced throughout anthropological literature, it is important to note that these territories do not have strict boundaries. They are general guides for the most common and importantly used resource and settlement areas for each of these First Nation groups around the time of contact with European settlers. As with the history of any human population, cultural groups evolve, expand, take over, modify, and move over time based on a number of environmental, social, and resource driven reasons.

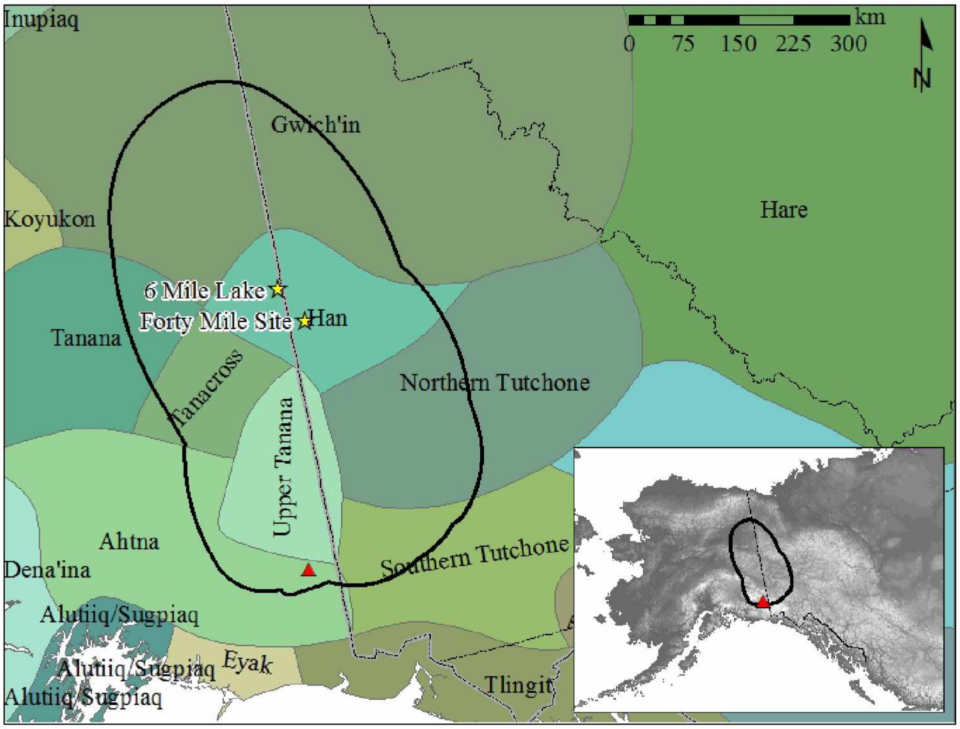


Figure 3.3 The Native Peoples and Languages Map of Alaska and the Yukon (Krauss et al. 2011), including the study areas.

For the purpose of this study the First Nation groups that will be addressed are the Tanana (specifically, the Upper Tanana and Tanacross), the Tutchone (which is composed of two linguistic subgroups, the Northern Tutchone and Southern Tutchone), and the Hän (with a focus on the Tr'ondek Hwech'in First Nation) (Figure 3.3). The Upper Tanana on the U.S. side of the boarder is one subgroup of the Tanana First Nation (McKennan 1969). The Tanana Chiefs Conference is the current organizational body that advocates and organizes 37 federally recognized tribes of the interior of Alaska incorporated under Doyon Limited. The study area located on the Canadian side of the border is within the Hän and the Tutchone traditional territories. The Tutuchone "were held together in the past by their contiguous territories, intermarriage, and their closely related Athapaskan dialects" (McClellan 1981:493). The current First Nations groups located within the study area include the White River, Kluane, Tr'ondek Hwech'in, and Selkirk First Nations. Due to the location of the case study, the focus of this background will be on the Tr'ondek Hwech'in First Nation. There are also a number of periphery groups that are not located directly within the study area. However, they no doubt had influence and connection with the First Nations lifeways being explored here. These include the language groups of Ahtna and the Tanacross, Upper Tanana and Hän of the Tanana groups, as well as the Yukon First Nation groups of Champagne & Aishihik, Little Salmon Carmacks, and Na-Cho Nyak Dun.

3.2.2 Territory

The Upper Tanana region is focused around the watershed of the Tanana River, beginning around the uppermost tributaries at Scottie Creek and Chisana River (possibly even as far east as the Snag River drainage), and downstream as far as Tetlin Junction and Tetlin Lake (Case 1986). This region extends as far north as the West Fork of Ladue River and the East fork of Fortymile River, and as far south as the edge of the Wrangell Mountains (McKennan 1981). McKennan (1959) notes that it should be remembered that this was a small nomadic hunter-gatherer group who traveled over the area based on the season, resource availability, and sometimes by chance.

The Hän occupy the heavily forested areas along the middle Yukon River, upstream of the Yukon Flats, between Bonanza Creek and Thanksgiving Creek, extending as far west as 60 to 80 kms on either side of the Yukon River (Mishler and Simeone 2004). Numerous large tributaries flow into the Yukon River in this region including: the Klondike, Fortymile, Seventymile, Charley, Nation, Kandik, and Nation rivers. These rivers and their tributaries provided access to the hills and mountains nearby. According to Osgood (1971), while the Hän did travel and hunt animals throughout their territory all year, they were more focused and reliant on fish as their primary resource.

The Tutchone region covers a large portion of central and southern Yukon. The Northern Tutchone extend as far east as the Selwyn Mountains and Ross River, and as far north as the Stewart River headwaters. Whereas, the Southern Tutchone extended as far east as Lake Labarge and modern-day Whitehorse. The current Alaskan border serves as its western extent, while the St Elias Mountain Range serves as a southern limit. McClellan (1981) notes the Tutchone were a highly mobile population that adjusted their movements based on resource availability and in response to conflict or activities of other First Nations or whites.

3.2.2.1 Relationships Between First Nation Groups

The specifics of the pre-contact relationship between groups are unknown; however, many ethnographers have noted connections between them from firsthand accounts or oral sources. It is inferred that the Upper Tanana and the Tutchone groups frequently interacted for trade and intermarriage (McClellan 1981). McKennan (1981:565) notes that the headwaters of the White

River and Snag drainages, were previously used by the Tanana; although, a 'war' with the Southern Tutchone interrupted this usage, "which was still a vivid part of native legendary history in 1929." There are historic accounts of 19th century relationships between the Upper Tanana, Tutchone, Hän, and Ahtna in the White River area in terms of control over the local native copper resource and trade with white men for goods. One specific account McClellan (1981:494) provides is:

> "Intergroup trade sometimes led to feuding. Indeed, the arrogance of several Southern Tutchone headmen toward their Upper Tanana trading partners (combined with trouble over stolen women) finally lead to the Upper Tanana to massacre most of the Southern Tutchone from Neskatahin (Old Dalton Post) while they were at their spring fishing camp."

It is speculated that this event took place in the 1850s and considerable tension resulted even after trade resumed (Workman 1978).

The Tr'ondëk Hwëch'in First Nation, whose main population center is Dawson City, identifies themselves as "descendants of Hän-speaking people who lived along the Yukon River with family genealogies from Gwich'in, Northern Tutchone and other language groups" (Tr'ondëk Hwëch'in 2015). Similarly, the White River First Nation describe that they are "closely related through traditional marriages between various local bands… [and] were merged by the Canadian government into a single White River Indian Band in the early 1950s for administrative convenience" (White River First Nation 2013). This amalgamation is common throughout the Yukon, where many First Nation groups identify with multiple language groups and traditional bands. The fact that both of these Canadian First Nation groups identify with varied ancestry provides evidence that these groups, while unique in many ways, were in contact with one another regularly and shared a commonality on some level.

3.2.2.2 Population

The demography of these groups from historical records are largely rough estimates due to the lack concrete census data and limited understanding of the cultural groupings of the First Nations by white travelers in the 1800s. Osgood (1971) attempted to compile data from both Yukon and Alaskan sources on populated Hän villages before European contact (from 1880 to 1910) and established a population estimate somewhere around 1,000. Notable villages included

Charley Village with 48 people, Eagle with about 200, Forty Mile (or Fetutlin) with 106, and Nuklako with a range of accounts from 82 to 200 (Osgood 1971). In the 1960s, an approximation of Hän individuals living in Dawson and Eagle was totalled to between 265 and 300 (Crow and Obley 1981). The first Tutchone population reference recorded was in 1842 in the Fort Selkirk region by Campbell, who describes a "large band" (Osgood 1971). Subsequent references describe specific bands or gatherings of Tutchone people anywhere from 15 to 250 people (McClellan 1981). Official census data from 1944 to 1974 list Tutchone populations anywhere from 133 to 1,580 individuals (McClellan 1975). Henry Allen (1887) first referenced the Upper Tanana population in 1885, estimating the population at around 97 individuals. However, this was simply evidence from one village in the region and by no means an extensive count. McKennan (1959) conducted a more thorough calculation in 1930 and reported 152 individuals spread between 5 different settlements. The occupancy of these settlements ranged from 16 to 59 inhabitants, which could be typical of the area for that time. However, there is no way to know for certain because of a lack of records.

3.2.2.3 Seasonal Round

It is known that traditional Dene/Athabascan culture in the study area was based on hunting, gathering, fishing, and trapping, combined with a high degree of mobility. Archaeologists and ethnographers have gained an understanding of the subsistence systems and settlement patterns employed by prehistoric hunter-gathers in the region. However, these recordings and interpretations are based on a small handful of research projects. In this area, access to water, stable resources, and lookouts were favoured both prehistorically and historically (Shinkwin et al. 1980). Typically, hunter-gatherer populations travelled in a seasonal round in order to gather necessary resources throughout the year (Table 3.1). While permanent camps were not established, semi-permanent or revisited campsites were typical and often part of the seasonal round.

Table 3.1 First Nation seasonal round, as recorded through ethnographic accounts.

	Spring Transition	**Summer** Plenty	**Fall** Prepare	**Winter** Rest and Wait
Upper Tanana	• Migratory waterfowl and eggs (ducks and geese) • Large mammals if possible (caribou) • Small mammals	• Whitefish, pickerel, grayling (eaten fresh and cached) • Waterfowl and their eggs • Small mammals (muskrats, squirrels, and more) • Roots, plants, berries (fresh and cached)	• Large mammals (caribou, sheep prime resources, early fall moose secondary) • Fishing until lakes close (Pike targeted)	• Large mammals (caribou primarily, moose only if necessary) • Small mammals (snowshoe hare, ptarmigan, grouse, furbearers) • Cached resources
Hän	• Birds (migratory geese, ducks, grouse, swans, loons, eagles) • Small mammals (lynx, rabbit, porcupine ground squirrel) • Plant resources (Hedysarium root, cambium)	• Salmon fishing (fresh and cached) • Greyling, pike, burbot, sucker (secondary resource) • Small mammals (lynx, rabbit, porcupine ground squirrel) • Game birds if available • Berries (fresh and cached)	• Large mammals (caribou, moose, sheep, bear) • Small mammals (lynx, rabbit, porcupine ground squirrel) • Plant resources (Hedysarium root, rhubarb, Labrador tea, and wild onion)	• Large mammals (Caribou) • Small mammals (beaver, lynx, rabbit, porcupine ground squirrel) • Cached resources
Tutchone	• Whitefish (during the spawning) • Small mammals (beaver gopher, muskrat • Waterfowl and migratory birds • Large mammal (moose when possible) • Plant resources (Hedysarium root, inner bark of cottonwood, poplar, and spruce)	• Large mammals (Moose, caribou, sheep) • Waterfowl and birds (ducks, ptarmigan) • Small mammals (marmots, rabbits and squirrels) • Freshwater fish and Salmon if available (fresh and cached) • Berries (fresh and cached)	• Large mammals (caribou and sheep, moose before the rut) • Small mammals (gophers especially) • Plant resources (Hedysarium root especially)	• Small mammals • Fishing if possible • Cached resources

Sources:
Upper Tanana: Allen 1887; McKennan 1959; McKennan 1981; Halpin 1987; Haynes and Simeone 2007
Hän: Schwatka 1900; Schmitter 1910; Osgood 1971; Crow and Obley 1981; Mishler and Simeone 2004
Tutchone: McClellan 1975; Workman 1978; McClellan 1981

3.2.3 Archaeological Background

The cultural chronology for this time period in Yukon-Alaska includes the Northern Archaic tradition (~5,000 cal BP) to the ethnographic present. The widely accepted sequence for southwestern Yukon is Workman (1979) with minor adaptation by Hare et al. (2008), and for central Alaska is Dixon (1985). These sequences "largely agree on basic traditions and chronology, but disagree on details like the presence or absence of certain technologies and the nature of transitions between traditions" (Potter 2016:539).

In Alaska, the Northern Archaic tradition spans from ~5,000–3,500 cal BP. The term 'Northern Archaic' was developed by Anderson (1968) who saw a connection with the technology of the Archaic tradition located in the southeastern United States that was adapted to a woodland lifestyle at roughly the same time period (Esdale 2008). This tradition is broadly characterized by: side-notched bifaces, semi-lunar bifaces, scrapers, large unifaces, notched pebbles, and hammerstones (Anderson 1988). This time period exhibits increased seasonal procurement of caribou and sheep in upland areas (Esdale 2008; Potter 2008a). It has been suggested that this cultural tradition and associated toolkit are associated with ecotone regions where people were able to take advantage of resources in both wooded and open areas (Mason and Bigelow 2008). The Late Denali complex spans ~3,500–1,500 cal BP and was characterized by the reappearance of microblade and burin technology, in addition to the Northern Archaic toolkit (Anderson 1988).

This is followed by the Athabascan tradition that spans ~1500–100 cal BP and is defined by a technological change that de-emphasized lithic tools and had an increase in tools made of organic materials and native copper. Other notable features include a higher frequency of fire-cracked rock, reliance on food storage and large habitation areas, increased use of birch bark, absence of microblades, stemmed projectile points, and arrowheads made of bone and antler (Dixon 1985). The transition between Northern Archaic and Athabascan traditions may represent a transition from high-mobility broad-spectrum hunting to logistically organized fishing-hunting practices (Potter 2008a).

In southwest Yukon, the cultural chronology contains many similarities to the previously defined Northern Archaic tradition. The Taye Lake phase spans from ~5000–1250 cal BP and was seen as geographical variant of the Northern Archaic tradition (Workman 1978). From a toolkit perspective, it includes notched or lanceolate points, large bifaces, thick unifaces, endscraper varieties, developed bone industry, and the absence of microblades/cores and native copper (Workman 1978). Large, multicomponent sites are suggestive of seasonal rounds that included reoccupation of favourable locations for hunting and fishing (Clark 1991).

The WRAe has been used as an arbitrary separation for the transition between the Northern Archaic tradition (Taye Lake phase) and the Late Prehistoric period in southwestern Yukon (Heffner 2002). The tephra fall is currently dated 1014–1256 cal B.P. (Clague et al. 1995); however, for consistency, researchers continue to utilize the date 1250 cal BP as the boundary age for the archaeological phase transition. While this thick band of ash is a useful stratigraphic marker between the two identified phases, Workman (1978) postulated a migration from the region following this event but also identified there was also some degree of cultural continuity across this horizon, with limited abrupt shifts in technology occurring.

The succeeding Late Prehistoric period (previously Aishihik and Bennett Lake phases) spans ~1250 cal BP and continues until the arrival of European trade goods. Hare proposed amalgamating the previously defined Aishihik and Bennett Lake phases (MacNeish 1964, Workman 1978) into the Late Prehistoric period as a movement away from these designations and towards a more regional characterization "with clear affiliations to modern Athabaskan groups" (Hare 1995:125). Characteristic artifacts include, diminutive side-notched points, small stemmed Kavik points, multi-barbed bone points, endscrapers with rounded outlines, stone wedges, native copper implements, ground slate, along with a general reduction in flaked stone industry (Workman 1978). Sites are small and likely reflect ethnographic settlement patterns (Heffner 2002). This period is closely linked with the Athabascan tradition identified in neighbouring Alaskan sites. Due to the scarcity of well-stratified sites containing dateable organics in the Southern Yukon, technological sequences have been based on as little as seven detailed excavations in the region (Hare 1995). These limited data sets form a cultural chronology that is widely accepted for the region, and are often applied in other regions of the territory when no other means of sequencing has been developed.

3.3 Case Study Localities Background

As previously mentioned, this project focuses on two localities in order to investigate the potential effects that the WRAn eruption had on the environment and Indigenous populations. These locations were chosen due to the body of work previously conducted and their relative proximity to one another (~55 km as the crow flies). The archaeological data was acquired from the Forty Mile Site (LcVn-2) and the paleoecological data was acquired from 6-Mile Lake.

3.3.1 Forty Mile Site (LcVn-2)

The Forty Mile Site (also known as Ch'ëdä Dëk) is located at the confluence of the Fortymile and Yukon Rivers, 88 km downstream of Dawson City and 67 km upstream from the US/Canadian border (Figure 3.4). For clarity moving forward, Forty Mile will be used when referring to the town site, and Fortymile when referring to the river. The area had been recorded as a First Nation encampment for hunting and fishing previous to the arrival of white settlers in the region. Dawson (1889) notes in his 1887–88 exploration report that there were Hän peoples present near the mouth of the Fortymile River. In addition, Osgood (1971) states that there was evidence of a sizeable settlement in the area prior to 1880.

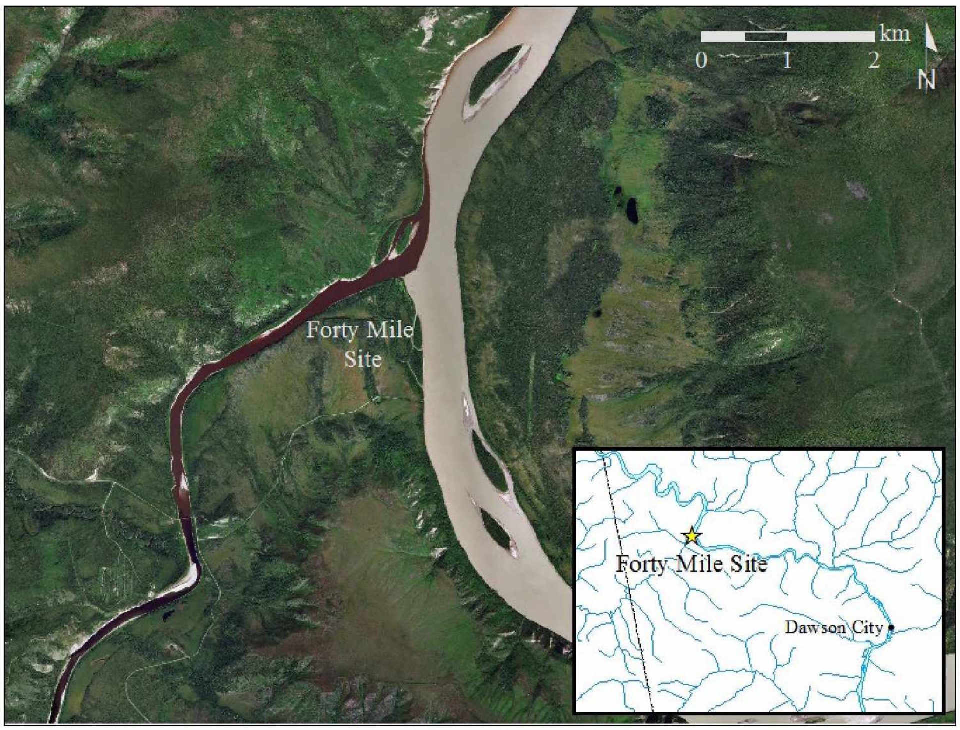


Figure 3.4 The Forty Mile Site area.

Previous archaeological investigations at Forty Mile have provided substantial evidence of repeated occupations over the past 2400 years. This is supported by recorded traditional knowledge that the Hän had been using this area prior to the presence of Euroamericans as a prime location for caribou hunting and fishing (Osgood 1971; Mishler and Simeone 2004). While numerous excavations have been conducted (between 1998 and 2005), a formal comprehensive analysis of the site has yet to be accomplished. Of particular interest are the excavations at what is termed the 'Mission locality' or Anglican Church and Mission (ACM) locality at the south end of the current

Historic site (Figure 3.5), as these exhibit the oldest occupations. The ACM locality features multiple archaeological components both above and below the WRAn (Thomas 2004), and encompasses a wide range of faunal specimens, bone tools, birch bark fragments, and lithic artifacts.

Figure 3.5 The Forty Mile Site with the North and Mission (or ACM) localities identified.

In 1886, a gold strike occurred at the confluence of the Fortymile and Yukon Rivers. The next winter, 30–40 men had established a small community there and a few years later Forty Mile became Yukon's first townsite, located almost directly in the center of Hän territory. The first building was erected in the summer of 1887 and the Forty Mile area began to attract miners, missionaries, trappers, Northwest Mounted Police (NWMP), and farmers in the region for the next nine years (Gates 1994). In the height of the Forty Mile stampede around 600 people were said to have been living at the townsite, including Fort Constantine and Fort Cudahy located on the northern side of the Fortymile River. The town was a supply center for all miners in the region and boasted a wide variety of stores and services, including six saloons, two bakeries, two restaurants, multiple churches, a schoolhouse, one or two dancehalls, two doctors, a barbershop, two blacksmiths, a tailor, a hardware business, trading post, a sawmill, a NWMP detachment, a theatre, multiple distilleries, and even a few prostitutes (Gates 1994).

The town of Forty Mile thrived as the main supply center for the area for about 10 years, until the discovery of other more profitable gold fields began to reduce the population, specifically Circle City in 1893 and Dawson City in 1896. The NWMP continued to occupy the Forty Mile post in order to monitor the transportation of goods crossing the nearby US/Canada border until 1938 (Gates 1994). A few trappers and fishermen continued to live in what was left of the town until 1958. Today, there are about 12 buildings still standing and a main cemetery with over 40 grave markers. The site is protected under the Historic Resources Act and the Tr'ondëk Hwëch'in Final Agreement, and is jointly owned and managed by the Tr'ondëk Hwëch'in and Yukon Governments. Stabilization and preservation of the standing structures are ongoing and the site includes a modern campground for paddlers and hikers to visit and learn about the history of the area.

3.3.1.1 Previous Fieldwork and Excavations

The Forty Mile Site has seen 9 previous years of fieldwork (Pollock and Newton 1981; Hammer 1999, 2000, 2001, 2002a, 2002b; Thomas 2004, 2005, 2006), with six of these investigations involving subsurface testing. Excavation at the site included a total of 92 shovel tests and 35 1 x 1 m test units. In total, 3454 collection records were assigned with a reported total quantity of 8206 artifacts and specimens.

In 1981, a magnetometer survey was conducted in order to identify any potential issues for future restoration work, such as foundation stabilization work. The crew focused on the area surrounding the Northwest Mounted Police (NWMP) Post, the Telegraph Station, and the Anglican Church. During their survey they noted that there was evidence of a prehistoric occupation in the vicinity of the Anglican Church due to the presence of stone flakes and a few fire-cracked rocks (Pollock and Newton 1981). They also noted that, "the historic disturbances on site, however, have negated any hope of recovering meaning information from the prehistoric remains" (Pollock and Newton 1981:4).

In 1998, a crew of three undertook seven days of field investigations. The foci of the project were to conduct a surface survey of the historic occupation extent, as well as locating the physical evidence for a prehistoric presence. The crew excavated 29 shovel tests (Figure 3.6) along the shorelines of the site at the Northern locality and recovered some fire-cracked rock and fragmented bone. A single chert flake was noted within an old fire pit, 60–65 cm below surface (cmbs)

(Hammer 1999). Additional testing was recommended due to the limited shovel tests that were conducted during this survey.

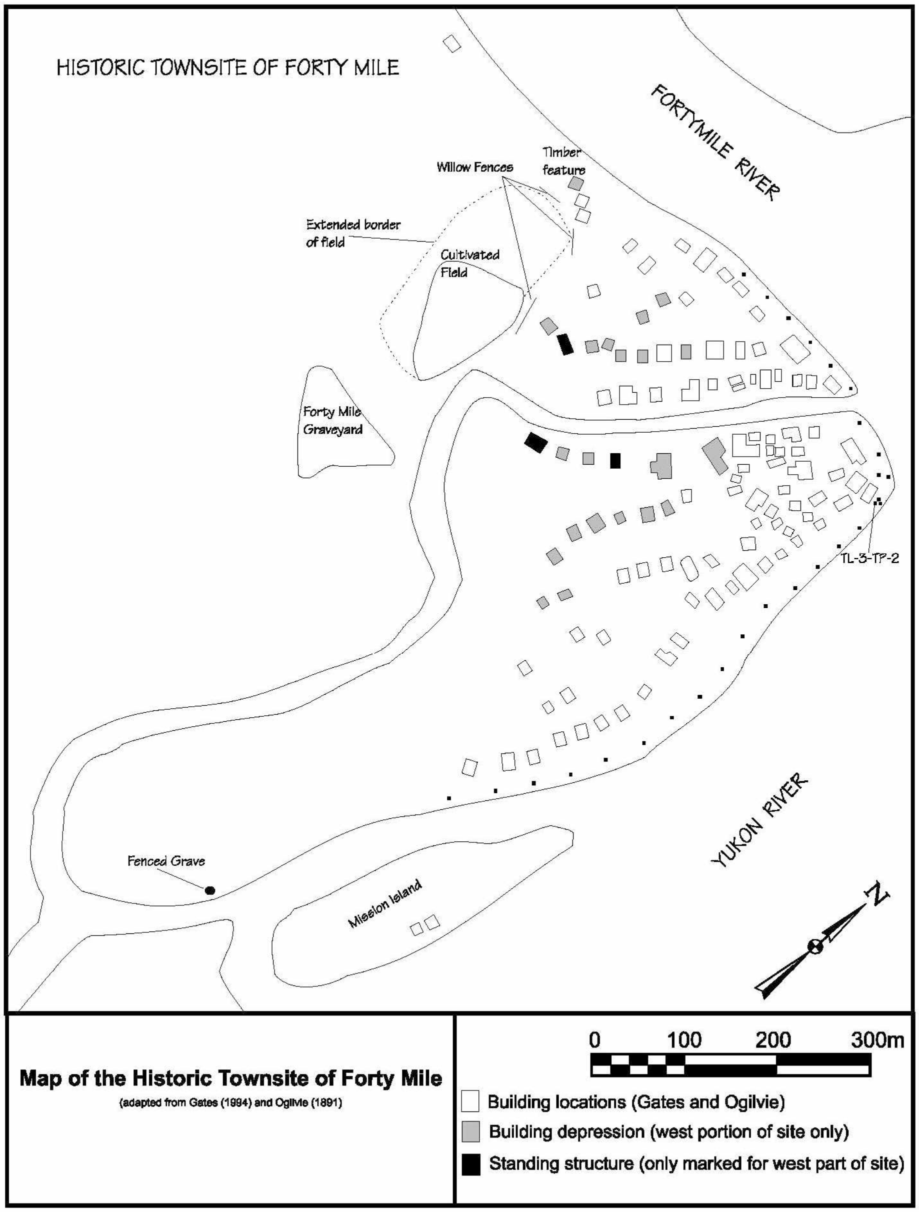


Figure 3.6 Map of Historic Townsite of Forty Mile and 1998 field tests (from Hammer 1999:3).

In 1999, a crew of seven undertook five days of field investigations at the site, in order to follow up on the previous year's work. The scope of the 1991 project was to focus on the Fort Cudahy and Fort Constantine localities for historic remains on the north side of the river confluence. In addition, further testing around the positive test pit from 1998 at the tip of the confluence was conducted. The crew excavated 22 test pits, two of which were 1x1 m units. Two hearth features were uncovered and artifacts included worked bone, lithics, and burnt bone (Hammer 2000), as well as a post-contact occupation involving glass beads and a birch bark basket.

In 2000, a crew of eight undertook eight days of site assessment at Forty Mile. The objective of this trip was to continue the historic survey, inventory, and mapping of the site. No subsurface prehistoric investigations were conducted this year (Hammer 2001).

In 2001, a crew of ten conducted nine days of fieldwork at the site at the North locality. The goal of this work was to map and test historic features, and sample the First Nation components of the site. Units were excavated with trowel by arbitrary 5 cm levels and screened with 1/8-inch mesh. Artifacts were placed in bags according to level, unit, and quadrant. Three-point provenience was recorded for significant artifacts. Excavation ended when sterile deposits or a significant feature were encountered. Unit wall profiles were drawn and photographed to further establish a general stratigraphy and context for features. Fourteen 1x1 m units were excavated with four features documented (Hammer 2002a). Three were identified as prehistoric hearths and the fourth was a historic midden "where numerous items of First Nation, European and a blended nature were recovered" (Hammer 2002a:61). Artifacts recovered from the site include a stone adze, end scrapers, lithic debitage, fire cracked rock, worked and burnt bone, and birch bark fragments. Two of the prehistoric hearths were radiocarbon dated to 480–29 cal yr BP and 630–600 cal yr BP. A lithic analysis was conducted and compared to the results from the Tro'chëk site (LaVk-10) and presented at the 2002 Alaska Anthropology Association Meeting in Anchorage (Corriveau and Hammer 2002).

In 2002, the crew returned in an attempt to complete a stretch of units began in 2001 and to continue with the mapping of historic features. A total of six weeks were spent on site with eight crewmembers. Ten units were excavated (1x1 m) and 12 shovel tests were placed along the Yukon River shoreline, starting at the confluence and continuing south (Hammer 2002b). Some of these tests were also conducted judgementally on Mission Island. Excavation methods were replicated from the 2001 season. A preliminary report was published; however, a final report with catalogued and analyzed artifacts, stratigraphic profiles of 2001–2002 excavations, recommendations, and conclusions was never published due to constraints on the lead researcher (Christian Thomas, Tourism and Culture, Yukon Government, personal communication 2018).

In 2003, a crew of three, lead by Christian Thomas, conducted ten days of archaeological fieldwork. The crew conducted impact assessments for three areas of the site: the Anglican Church and Mission (ACM), the Royal Northwest Mounted Police (RNWMP) Post, and a locality adjacent to the Alaska Commercial Company store (ACC). Further testing at the ACC locality was not conducted due to previous excavation in the vicinity and the amount of large historic objects in the area. A surface inspection was conducted and recommendations for the best location for a cook shelter were discussed (Thomas 2004). Shovel testing was conducted around the RNWMP Post and produced a collection of historic finds, one piece of fire-cracked rock, and the WRAn was encountered. Testing was not possible beyond the layer of tephra due to frozen ground. Subsurface testing was also conducted around the Anglican Church and Mission (ACM) building, referenced as the Mission locality in this report. Eleven test pits were dug, 6 of which had prehistoric remains. Since the plan was to stabilize and replace the building's foundation, which could cause subsurface disturbances at and around the structure, it became apparent that additional assessment would be necessary at this location (Thomas 2004). To begin this assessment, four 1x1 m Units were excavated, chosen from the test pits with the most significant finds (Figure 3.7). Three of the units were excavated to 35–40 cmbs, all above the WRAn, due to frozen ground. One unit was excavated to 110 cmbs and uncovered three archaeological components, one above the WRAn and two below it. Three hearth features were identified above the tephra (Thomas 2004).

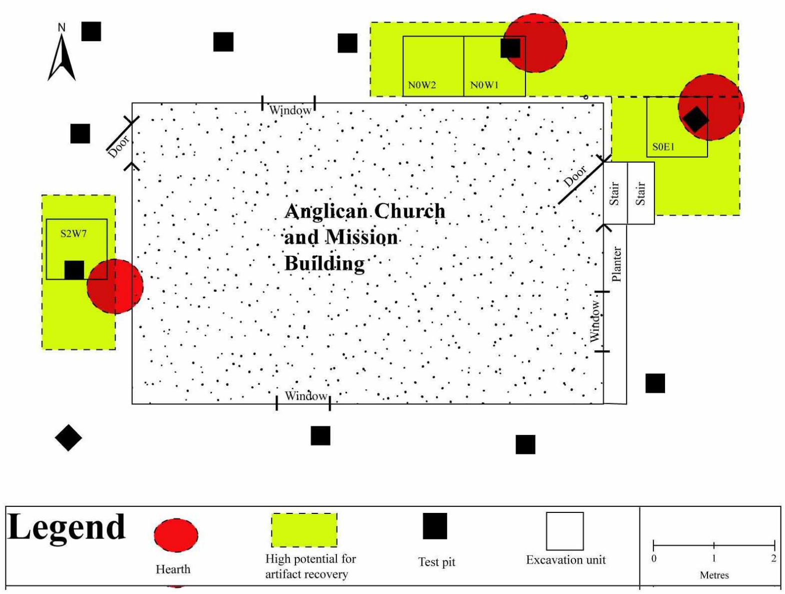


Figure 3.7 Map of ACM locality 2003 field tests and excavation units (from Thomas 2004:3).

In 2004, a crew of five continued the prior year's excavation around the ACM. An additional six units at 1x1 m and one unit at 1x0.5 m were excavated over 10 days (Figure 3.8). All units were dug to a depth of 40–50 cmbs or to the top of the WRAn. This extension of the excavation revealed a more complex stratigraphic profile and a total of six cultural components were realized from the original of three (Table 3.3) (Thomas 2005).

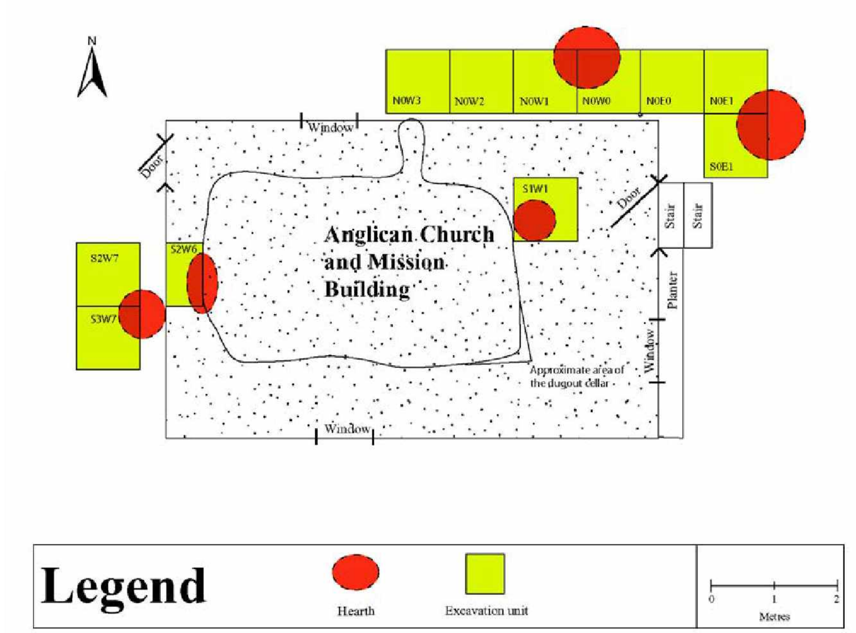


Figure 3.8 Map of ACM locality 2004 excavation units (from Thomas 2005:13).

Table 3.2 Cultural components identified at the ACM locality in 2003 and 2004 (adapted from Thomas 2004; 2005).

Cultural Levels	Description	Artifacts and Features
Component 1	Historic	Nails, glass, ceramics, beads, wallpaper, etc
Component 2	Pre-contact with some Historic in certain units	Lithic debitage, hearth features
Component 3	Pre-contact above WRAn	Lithic debitage, hearth feature, burned bone scatter
Component 4	Pre-contact above WRAn	Lithic debitage, bone
Component 5	Pre-contact below WRAn	Lithic debitage, lanceolate side-notched projectile point
Component 6	Pre-contact below WRAn	Lithic debitage, barbed notched projectile point, bone awl, bone, hearth

In total, 166 pre-contact artifacts were recovered. The majority of these artifacts consisted of lithic debitage, although an assortment of scrapers, cores, retouched and utilized flakes, and a bone awl were also recovered. It is important to note that while the faunal remains were recorded during this excavation and from previous excavations, there was no further analysis and they were not included in artifact counts. They will be included in overall artifact counts for this research project and further analyzed.

In 2005, a crew of four conducted fieldwork in the Forty Mile vicinity for ten days. The focus of the work was on archaeological testing at Forty Cudahy and Fort Constantine and mapping of historic features in the greater region including a First Nations Cemetery, the Percy De Wolfe Cabin, a number of isolated cabins along the Yukon River, and a small First Nation Village at Halfway Creek. No subsurface testing was conducted at the Forty Mile Site that year.

3.3.2 6-Mile Lake

6-Mile Lake (informal name; N 64° 52.02', W 141° 7.26', 304 masl) is located approximately six miles (10 km) downstream of Eagle, Alaska (Figure 3.9), and ~55 km northwest of the archaeological study site of Forty Mile (LcVn-2). The lake is about 600 m long and 170 m wide, with a maximum water depth of 20 m and is situated on a terrace ~20 m above the modern Yukon River. The lake has gentle shelves on the northern and southern ends and steeply dipping sides to the east and west. The lake shape and surrounding topography suggest that the lake lies within a former channel of the river (Bigelow 2014). Bigelow (2014:2) notes the vegetation around the lake as "typical boreal forest", with white and black spruce, birch, willows, and alder. Sedges and grasses dominate the lake margin and water lilies are present in the shallows.

Nancy Bigelow (2014) and colleagues cored the lake in 2010 as part of regional study on the effects of climate change on lake levels in interior Alaska. The results included a discussion of its stratigraphy, chronology, and depositional history. The study concluded that the lake had formed well before 11,000 cal BP and was within 4 m of current levels by 9,000 cal BP. Today, the lake level is as high as it has ever been (Bigelow 2014). The lake core was deemed to be appropriate for this project's pollen analysis given that: there was unanalyzed pollen within the core, no disturbance of mixing was evident, a basic chronology was established, and a 1 cm thick bed of WRAn tephra was present (Bigelow 2014).

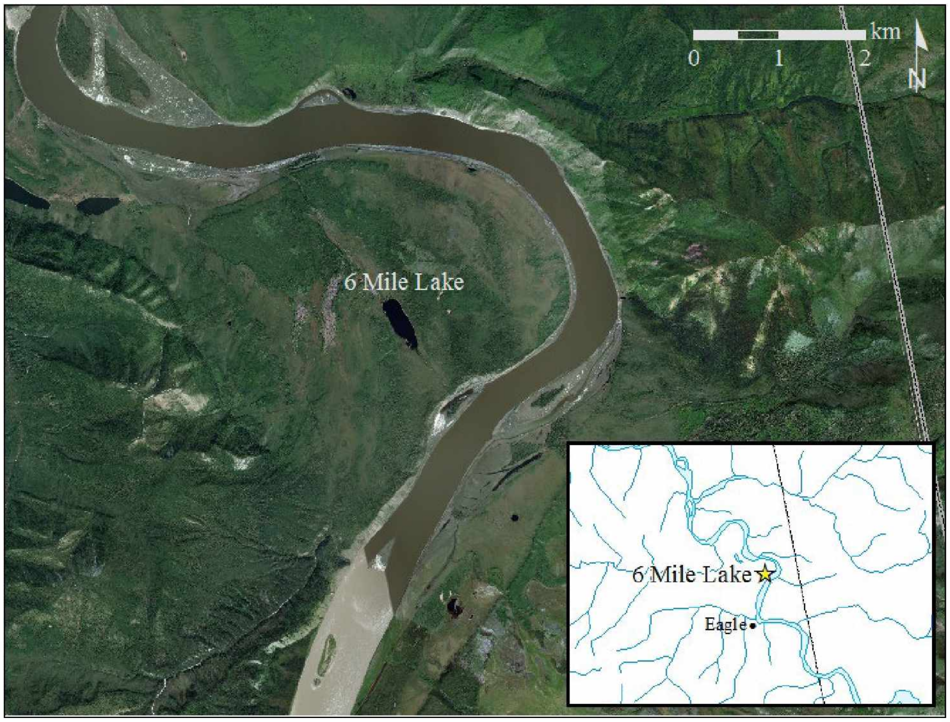


Figure 3.9 6-Mile Lake area.

Chapter 4: MATERIALS AND METHODS

This chapter outlines the materials and methods used in this study and is divided into two sections. Section 4.1 summarizes the pollen investigation techniques and methods for analysis; and Section 4.2 details the archaeological excavations at the Forty Mile and approaches of the analysis.

4.1 POLLEN ANALYSIS

This section summarizes the palynological portion of the study and includes the methods of site selection, processing and preparation of the samples, and details the procedures involved in pollen analysis. Radiocarbon sampling, age modeling, and pollen diagrams are also outlined.

4.1.1 SITE SELECTION

The most important variable in choosing a study site is identifying the specific research questions and then choosing a site that can provide the best data to answer those questions (Jacobson and Bradshaw 1981). For this portion of the study, the main research questions are twofold: what does the pollen indicate about the vegetation prior to and following the WRAn eruption, and do plant taxa recover and repopulate in similar proportions and abundance? Therefore, it was important that the study site that had WRAn tephra located within the core and a lake that was able to provide insight into the local and regional vegetation. 6-Mile Lake fulfilled these requirements.

The lake was previously cored in 2009 and 2010 when Bigelow and colleagues (Bigelow 2014) collected over 20 m of lake mud from five core sites at the lake. The cores were collected in the field with 2.75" diameter plastic tube and 2.5" diameter steel tube using a modified Livingstone lake sediment corer (Bigelow 2014). Plastic tubes were utilized for the sediment/water interface and the soft lake sediments. Steel tube was utilized for the deeper and stiffer lake sediments. Cores collected in the steel tube were extruded in the field into plastic pipe. Since collection, the cores were stored at 5°C at the Alaska Quaternary Center (AQC) lab on the UAF campus. While a myriad of analyses had been conducted on the cores, pollen had not yet been analyzed. Core 10-C (collected from 14.9 m of water depth) was chosen for this analysis because it already had a radiocarbon chronology (which was refined in this study) and the WRAn had been identified visually and chemically by microprobe analysis.

Once in the lab, the lake cores were split in half. One half was set aside for archival purposes, while the other half was designated the 'working' half and used for description and sampling. The original report included a wide variety of analyses including magnetic susceptibility, visual descriptions, water content, dry bulk density, loss-on-ignition, carbon and nitrogen analyses, microprobe analyses, tephra correlation, and radiocarbon dating. The WRAn was visible within the cores and as stated earlier it fulfilled requirements for preferred basin characteristics (size, depth, location, etc.) for pollen sampling based on the research questions. To conduct a high-resolution analysis of the pollen record for this region, the pollen samples were drawn from Drive 1 (D1) of a single core, the 10-C lake core (10-C D1) (Figure 4.1). The archival half of the 10-C core was utilized for the majority of the analysis for this project, due to the high level of previous sampling imposed on the working half of the core.

Figure 4.1 Image of 10-C D-1 during data sampling. The WRAn is visible. The measuring stick is 50 cm long. Photo taken by author.

4.1.2 Processing and Preparation

Pollen preparation and sample processing was conducted by Nancy Bigelow using conventional methods (Faegri and Iversen 1989). This included adding a known quantity of exotic pollen (tablets of *Lycopodium clavatum* spores) to the volumetric samples in order to calculate concentration (grains/cc) and influx (grains/cm^2/yr) as the entire sample was not counted. The samples were put through a series of treatments and sieving and were then mounted on slides with silicon oil (see Appendix A for pollen processing sheets). Prior to mounting slides, the samples were unstained and stored in vials with silicon oil.

The WRAn in the lake core was approximately 1 cm thick and located between 20–21 cm in drive D1 (or 95–96 cm below sediment surface). In total, 16 samples were processed from the 10-C D-1 lake core for analysis. In order to capture post-eruptive effects, 11 samples from above the ash, each 0.25 cm thick, in 0.25 cm increments were prepared (17.75–20 cm, D1 depths). To capture a pre-eruption baseline, samples were also prepared from below the ash; 4 samples of 0.5 cm, in 0.5 cm depth increments (21–23 cm), and one final 0.5 cm sample 1 cm below (24 cm).

4.1.3 Pollen Analysis

Counting was conducted in the AQC's Paleoecology lab using a Nikon Optiphot-2 light microscope. Magnification at 400x was utilized for the majority of the counts; however, 100x and 1000x were employed when necessary. Pollen reference collections in the lab were utilized for comparison and identification along with pollen keys including those by Faegri and Iversen (1989) and Moore et al. (1991). Nancy Bigelow oversaw quality control and verification of pollen during the counting process. Samples were mounted on glass slides in silicon oil and secured at the corners with nail polish. When necessary, multiple slides were created per level. A minimum of 150 pollen grains per sample were analysed from terrestrial trees, shrubs and herb/forbs. Full passes over the prepared slides on the microscope were conducted; if 150 grains were accounted for halfway through the slide, counting continued until the entire pass was completed. The added exotic pollen was also counted in order to calculate pollen concentration [grains(cm^{-3})] and influx [grains(cm^{-2})(yr^{-1})], in addition to percent calculations (Faegri and Iversen 1989). Spores and aquatics were also counted as identified. The decision to count a minimum of 150 grains was based on the newly acquired skill of the researcher, time limits, and the amount of pollen grains necessary to acquire an adequate representation of the pollen.

4.1.4 Radiocarbon Sampling

Six radiocarbon ^{14}C dates were previously ascertained from the 10-C core from Drives 2 through 4. In order to develop an accurate age model and sedimentation rates for drive D1, five additional sample depths were prepared for ^{14}C dating at various depths from the sediment surface to below to WRAn to create a more detailed age profile. Samples were sent to the University of Georgia's Center for Applied Isotope Studies (CAIS) for dating via accelerator mass spectrometry (AMS). This lab was chosen for consistency with the previous ^{14}C sample results to alleviate potential systematic differences between two labs. When possible, macro-plant fragments of terrestrial origin were used, or combined with *Picea* pollen, which was concentrated in the lab by Nancy Bigelow. In cases where no plant fragments were uncovered during sampling, *Picea* pollen was utilized on its own.

Identified plant macros were washed in reverse osmosis (RO) water and then dried; they were not pre-treated before sending to the CAIS lab for dating. *Picea* pollen was concentrated using heavy liquids and sieves. All the pollen preparation was done using distilled RO water. The samples were given one treatment of 10% HCl, several treatments of 10% KOH (in a boiling water bath), and several treatments with the heavy liquid Na-polytungstate (s.g. 2.0 and lighter), as well as sieving at 125, 90, and 20 microns. The pollen preparations were the fraction <90 and >20 microns. These methods broadly follow the protocols established by Brown et al. (1989) and Vandergoes and Prior (2003). None of the samples were weighed due to fears of sample loss during the process. The pollen samples were prepared, placed in vials, and kept cool and moist through delivery to the CAIS. Plant material samples were dried and also placed in vials.

4.1.5 Age Model

Once the ^{14}C dating results were received from the CAIS lab, this information was utilized in combination with the six previous ^{14}C dates from Drives 2 and 4 (see Appendix B for radiocarbon results) in order to create a comprehensive age model for the lake core. Age models combine ^{14}C dates and calibration results with lake core depth in order to determine the sedimentation rate and ultimately the chronology for the lake core. For this study, Clam (Blaauw 2010) package version 2.3.2 was used within the free open-source statistical software R to make the age model. The northern hemisphere terrestrial calibration curve IntCal13.14C (Reimer et al. 2013a) was utilized in the calibration process. The settings applied to obtain the age-models are included in the Appendix C. The second order polynomial regression was used as it had the best fit with the accepted dates. Fluctuations in the Earth's geomagnetic forces, nuclear testing, and the ever increasing burning of fossil fuels has caused the concentration of ^{14}C in the atmosphere to vary over time (Reimer et al. 2013b). Calibration of ^{14}C data is necessary in order to convert the acquired conventional dates into calendar years.

Because the calculated age of the WRAn in the 10-C lake core does not agree with the terrestrial age in Lerbekmo et al. (1975) and Reuther (2019) (this is further discussed below), I set the tephra age to zero years and corresponding depths above and below the core were allocated ages in relation to years before (plus) or after (minus) the WRAn based on the age model (as previously conducted by Blackford et al. 2014). The age model outputs were then entered into the paleontological software program Tilia ver. 2.1.1 (Grimm 2016), in order to generate the y-axes presenting both the chronology and depth of the core. This data was utilized for both the summary and the influx diagrams described in the results.

4.1.6 Pollen Diagrams

Two diagrams were generated from the pollen analysis using the software program Tilia ver 2.1.1 (www.tiliait.com). The first is the summary diagram, which includes both the percent and concentration data. Pollen percentages are based on a variety of sums. The percentage of terrestrial trees, shrubs, and herbs is based on the sum of those taxa (the basic pollen sum). Whereas the percent of spores is based on the basic pollen sum plus the spores, and the percent of aquatics is based on the basic pollen sum plus aquatics. The use of multiple sums prevents spores or aquatics from overwhelming the terrestrial taxa. The concentration data is the count of pollen grains per cm^3 and does not account for the sedimentation rate. The second diagram presents the influx data, which is the number of grains per cm^2 per year. This takes into account the sedimentation rate and concentration of pollen grains. The y-axis presents both the sample depth within the core and the age of deposition, in years relative to the WRAn ashfall. In the diagram, certain taxa, specifically the herbs and forbs, where clustered together in order to display trends more easily. The summary graphs on the far right-hand side of the diagram were given colours in order to draw the reader's attention to the most significant portion of the results. This diagram compiles all of the palynological information gathered during analysis.

4.2 Archaeological Excavation

This section summarizes the archaeological portion of the study and includes the process of site selection, methods of excavation, and details the artifact collections to be utilized in this study including the variables considered for analysis. Finally, the limitations of the archaeological portion of the study are outlined.

4.2.1 Site Selection

There are a limited number of excavated archaeological sites within the WRAn study area, on either side of the Alaska-Yukon border, which made selecting a site for this analysis challenging. The opportunity was presented to conduct additional excavations at a site that had several previous historic and prehistoric excavations. The Forty Mile Site (LcVn-2) is unique because it is located approximately 340 km north of the volcanic complex, has a distinct layer of tephra throughout the landform, and is a multicomponent site with recorded occupations both below and above the WRAn. While sites in Tok – The Terrace Site (Sheppard et al. 1991) – and Scottie Creek – The Little John Site (KdVo-6) (Easton 2014) –, have also been excavated and contain multicomponent sites, both locates are in close proximity to Mt. Churchill and could have possibly experienced disturbances by both the WRAn and WRAe eruptions.

Once the site was selected, a review of previous site reports was conducted. In addition, meetings were arranged with Government of Yukon and Tr'ondëk Hwëch'in First Nation (THFN) staff in order to determine the best ways in which to proceed with the study. Meetings were arranged in Whitehorse with the Government of Yukon and in Dawson with THFN.

4.2.2 2017 Excavation Methods

The precise location of further excavations was chosen in consultation with Christian Thomas of the Government of Yukon. We determined that the most ideal location for the 2017 excavation was an expansion of the most productive units uncovered in the ACM locality (ACM) conducted in 2005. The site datum and grid had been established previously; therefore, the first task was to relocate the excavated units and re-establish the baseline for the 2017 excavation. For site control, 2x1 m excavation blocks (with 1x1 m units) were established. These units were excavated by hand with trowels, generally in pairs. All matrices screened with 1/8" mesh. Artifacts identified were mapped, collected, and bagged according to excavation block, unit, quadrant, and level. Due to the abundance of historic artifacts encountered during excavation, these objects were collected in bulk and bagged for blocks per level. Artifacts were photographed *in situ* and mapped using a total station or by 5 or 10 cm layers and quadrant for artifacts recovered in the screen. Vertical depths were recorded either by the total station or from the established block datum corner and measured in with a line level and measuring tape. Organic materials encountered during the excavation that could be used for radiocarbon dating were collected in acid-free bags and/or tin foil and prepared for analysis in the lab. Field notes were written by crewmembers in excavation block notebooks and collected at the end of the project by the researcher. Soil profiles were photographed, mapped, and recorded by cultural and natural strata.

The excavation was conducted in partnership with crewmembers from the Government of Yukon and Tr'ondëk Hwëch'in First Nation of the Yukon as part of an archaeological community development project. This collaborative effort will provide opportunities for continued consultation and insight into all aspects of the site. The excavation was conducted over 30 days (3 shifts of 10 days each). Crewmembers participated for a variable number of days depending on availability, and along with the researcher, included: Christian Thomas, Dawn Bohmer, Lee Whalen, Nansen Murray, KC Campbell, and Sammy Taylor, Gavin P S, Luke Kormendy, and Marshall Jonas.

4.2.3 Artifact Collections

Given that this analysis incorporates material from nine additional years of fieldwork (Pollock and Newton 1981; Hammer 1999, 2000, 2001, 2002a, 2002b; Thomas 2004, 2005, 2006), it is important to note what portion will be used for this project. In total, six of the previous field investigations at the site involved subsurface testing. These included 92 shovel tests and 35 excavation units throughout the entirety of the site, of which only one unit and two shovel tests were dug beyond the WRAn. In total 3,454 collection records were assigned, with a reported total quantity of 8,206 specimens. In order to avoid the historic component, for this analysis, only specimens with recorded provenience of ~20 cmbs or more were selected. This resulted in a total of 503 collection records, with 3,065 individual specimens. These records included fauna, lithic, birch bark, and ochre samples.

4.2.3.1 2017 Excavation

Artifacts uncovered during the 2017 excavation include a range of historic and prehistoric materials. Historic artifacts were collected by level and catalogued in bulk for the interest of time by 1x1 m units. These objects include: nails, glass, metal, beads, ceramics, bullet casings, wooden planks, etc. Prehistoric artifacts were catalogued either individually or in groups based on their total station localities. These artifacts include bone (burned, fragments, worked), fire cracked rock, birch bark, and lithics. Samples of charcoal, pumice, and tephra were also collected. In addition, a few soil samples from productive features were collected and sifted with finer screens in the lab, in order to acquire a sample of micro-debitage and small bone fragments. In total, 3,714 artifacts were collected from the site, with 678 artifact numbers.

4.2.3 Radiocarbon Samples

From the previous reports, there were 6 components identified over the range of excavations, labelled from youngest to oldest. Component 1 is identified as historic/proto-historic, Components 2–4 as prehistoric pre-WRAn, and Components 5 and 6 as prehistoric post-WRAn (Table 4.1). The previous dates included charcoal from Component 5, that were in a cultural context (Thomas 2006) within the level a side-notched biface was identified, and dated to 2330±40 BP. Previous dating had also been conducted at the North locality at the confluence by T.J. Hammer (2002). Two samples from an occupation in the third organic level produced dates of 520±40 BP and 310±40 BP.

Table 4.1 Previous radiocarbon samples from the site (Acquired from Yukon Government artifact collections).

Year Submitted	Locality and Component	Material	14C age, years BP	±	Depth (cmbs)
2001	North – 3rd organic	Charcoal	520	40	69
2001	North – 3rd organic	Charcoal	310	40	70–75
2011	ACM – Component 2	Charcoal	68[1]	26	25–30
2011	ACM – Component 2	Charcoal	592	25	35–40
2013	ACM – Component 4	Charcoal	1590	30	65–70
2003	ACM – Component 5 (large side-notched biface)	Charcoal	2330	40	~90
2003	ACM – Component 6 (small side-notched biface)	Charcoal	2230	40	100–115

[1] These dates were suspect to contamination by the original investigator.

Directly after the excavation, examination of the field notes and collection were conducted in order to parse apart the cultural levels, depth below surface, and previously named components in order to find the most ideal samples for additional radiocarbon dating. The goal was to choose samples that had solid associations with cultural materials, covering each of the prehistoric components with at least one radiocarbon sample, and if possible, using multiple materials (charcoal and bone). When possible, identifiable bones were sampled. No more than two samples from each identified cultural component were chosen to avoid redundancy and limit expenditures.

Eight dates in total were sent to the AE Lalonde AMS Laboratory in Ottawa for radiocarbon dating (Table 4.2). Calibration was performed by the lab using OxCal v4.2.4 (Ramsey 2009) and the IntCal13 calibration curve (Reimer et al. 2013a) and sent along with the results. Once all the radiocarbon dates were acquired the raw dates were entered into Calib v7.04 (Stuiver et al. 2013) using the 2-sigma calibrated results in order to produce a complete picture of the chronology of the site.

Table 4.2 Radiocarbon samples sent from 2017 excavation for AMS dating.

Sample ID	Material	Cultural Component	Depth (cmbs)	Context
LcVn-2:1	bone	2	25–35	bone and lithic in context, hearth feature (red soils)
LcVn-2:2	bone	3	45–50	lithics in, pre/post level - pre WRAn - bone fragment identifiable (left ulna, moose)
LcVn-2:3	charcoal	3	50–55	lithic with charcoal pre-WRAn
LcVn-2:8	charcoal	4	60–70	charcoal from feature - bone cluster (level 12 & 13) lithcs associated, pre-WRAn
LcVn-2:4	bone	4	70–80	feature - bone cluster (level 12 & 13) lithcs associated, pre-WRAn
LcVn-2:5	bone	5	85–90	feature - bone and lithic cluster
LcVn-2:6	charcoal	5	105–110	charcoal cluster associated with lithic scatter and birch bark
LcVn-2:7	bone	6	115– bottom	feature - lithic scatter nearby, bone cluster, charcoal in level

4.2.4 Variables Considered

Archaeological sites have a range of variables that could be considered when conducting analyses. Based on the research questions and the previous analysis it was determined that the factors to be considered for this project would be chronology, faunal specimens, lithic debitage and artifacts, and spatial distribution.

4.2.4.1 Chronology and Stratigraphy

It is important on all archaeological sites to establish a chronology in order to identify the length of time that has passed at that specific location and provide an indication as to the occupation periods and cultural features that are present. Chronology of the site was determined using both absolute dating with radiocarbon analysis, and relative dating with the WRAn tephra and stratigraphic evaluation.

In order to acquire a more detailed representation of the cultural occupations expressed at the site, eight new samples were selected from the cultural components to be submitted for radiocarbon dating. In addition, previously submitted radiocarbon dates and identified cultural components were utilized to assist in analyzing the artifacts. Additional radiocarbon dates made it possible to parse apart the time between occupations and provide an indication as to how long the site was utilized by people.

The stratigraphy of the site seems to differ depending on the location. The Forty Mile Site is situated on a unique landform on the southern side of the confluence of the Yukon River and Fortymile River. There are a number of side channels on either side of the confluence that have created islands over time, or have transitioned into sloughs depending on the water levels (Figure 3.5, from Chapter 3). An old river channel that has now become a slough currently cuts around the main portion of the Forty Mile Site. This portion has been termed Forty Mile Island, and is the location of the archaeological investigations for this project. Within this landform there are also two distinct topographies; the lower bench directly at the river confluence and the raised river terrace located about midway. The previous excavations located at the confluence did not seem to encounter any WRAn within their units. They were dominated by more sands and less stratigraphic integrity. The previous portion of the site that was excavated beyond the WRAn at the ACM locality (Anglican Church and Mission) and produced a richly layered stratigraphic profile, which displays multiple layers of light silts and organic stained silts, interspersed with cultural components, river cobbles, and a distinct band of WRAn tephra (Figure 4.2). These stratigraphic differences observed in such a short distance indicates the power and changeability of the two rivers and the natural flood cycle, particularly at the confluence.

The WRAn tephra was used as a relative date in order to segment artifacts between pre-ash and post-ash. Regardless of any possible inconsistencies with the absolute dating, the tephra acts as a way to distinguish distinctly between cultural components that occurred before or after the volcanic eruption circa 1625 cal BP (Reuther et al. 2019).

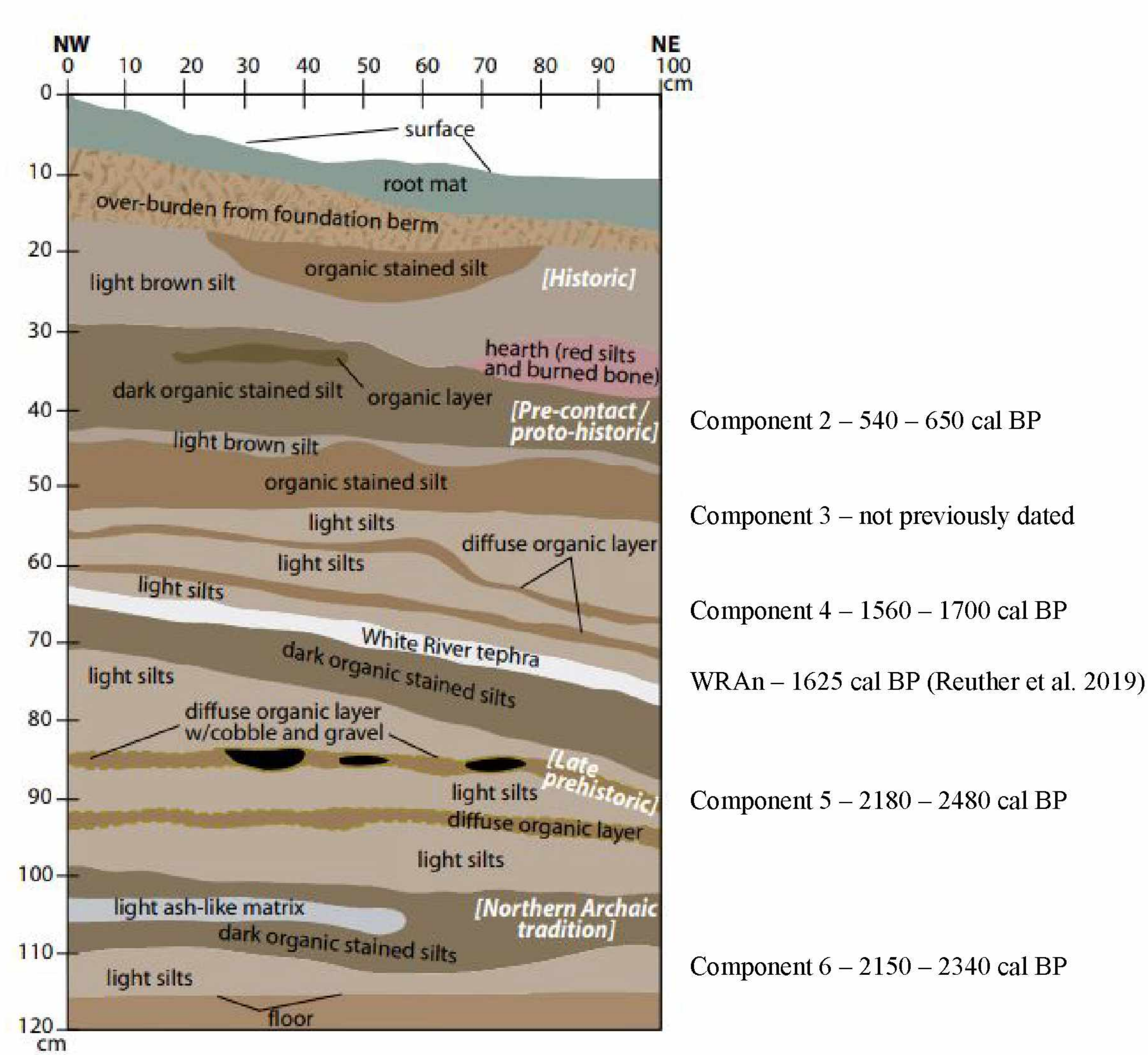


Figure 4.2 Soil stratigraphy and dates from previous excavations (from Hammer and Thomas 2006).

4.2.4.2 Faunal

Data collection for the faunal material was conducted in the University of Alaska Fairbanks Anthropology Department's Zooarchaeological Laboratory and the Government of Yukon's Palaeontology laboratory. The fauna was analyzed following standard zooarchaeological procedures (Lyman 1994; Reitz and Wing 2008). Identifications were conducted with the assistance of Dr. Jamie Clark and Dr. Ben Potter from the University of Alaska Fairbanks and Elizabeth Hall of the Yukon Paleontology Program. Data was recorded in two separate Microsoft Excel spreadsheets, one for previous specimens and another for specimens from the 2017 excavation. This was due to the variability in excavation methods and detail of recording. In addition, the previous excavations had already been catalogued and curated, whereas the 2017 excavation required initial cataloguing, final reporting, and data transfer to the Government of Yukon.

All faunal material was analyzed for a number of attributes. Individual specimens were weighed, measured, and identified to element portion and closest taxon or size class. Bones that were recovered in lots were recorded collectively and given weights, but not measurements. Taphonomic features such as burning, root etching, cut marks, and acid wear were visually identified and coded for presence and absence utilizing the *Atlas of Taphonomic Identifications* as a reference guide (Fernández-Jalvo and Andrews 2016). Taxonomic identifications were made utilizing the University of Alaska Fairbanks Department of Anthropology Zooarchaeological comparative collection and Government of Yukon's Palaeontology comparative collection, and when necessary, the Idaho Museum of Natural History virtual museum (https://virtual.imnh.iri.isu.edu).

As stated, all identifiable specimens were assigned a size class. The categories follow a modified version of Thomas' (1969) classification system defined by live animal weight ranges. Thomas created the system in a region that was dominated by small fauna; as the project area includes larger species, Thomas' classification system was adapted to incorporate the range of species in Alaska/Yukon. It was important to tease apart species such as moose and caribou, as they would be affected by tephra deposition differently due to their preferred diets. The five size class categories used for this project consists of: very small (<100 g), small (100 g–700 g), medium (700 g–25kg), large (25kg–180kg), and very large (>180 kg) (Table 4.3). Due to the small sample of identifiable specimens in the collection, further faunal analyses were not conducted.

Table 4.3 Size class categories as modified from Thomas (1969).

Class	Weight	Examples
Very Small	<100g	Microtine
Small	100g – 700 g	Squirrel
Medium	700g – 725kg	Hare, Fox, Porcupine
Large	25g – 84kg	Caribou, Dall Sheep, Wolf
Very Large	>84 kg	Moose, Bison, Bear

Due to the small number of identifiable faunal remains, qualitative and analytical procedures used in this analysis were limited to the number of identified specimens (NISP) and a consideration of the spatial context from where the remains were located. The number of identified specimens (NISP) is defined as the sum of skeletal elements, including both bones and teeth and fragments thereof identified to taxon (Lyman 2008). For the purpose of this research, NISP refers to any fragment identifiable to size class, animal type (i.e., rodent, ungulate, bird), taxon (species, genus, or family), and element. I calculated the NISP values by tallying the total number of bone, tooth and antler fragments, with the entire elements by species, animal type, and size class.

4.2.4.3 LITHIC DEBITAGE AND ARTIFACTS

Data collection for the lithic material was conducted in the Government of Yukon Archaeology Program's laboratory. All debitage from the 2017 excavation, n=1043, was analyzed. The sample size was considered sufficient as a representative sample due to confidence in stratigraphic localities and total lithics present at the entire site. All statistical outputs were generated using JMP version 13.2.0. Due to the limited number of tools identified from the entire Forty Mile Site collection (8 scrapers, 12 utilized or retouched flakes, and two bifaces), a comparative analysis of tools was not conducted. Instead, tool analysis is limited to a consideration of typological attributes. The formal tools were considered in conjunction with other artifacts uncovered at the site including birch bark, modified bone tools, and fire-cracked rock in order to place the site within the context of previously identified cultural chronologies.

Debitage analyses were conducted by cultural component and in larger pre/post ash level groups in order to address the broad questions relating to lithic technology at the Forty Mile Site: What reduction strategies occurred primarily in the assemblage? Are there observable differences in lithic behaviours between pre-WRAn eruption and post-WRAn eruption? How can these inform on mobility before and after the WRAn ashfall? The research questions guided the specific analyses and attributes recorded.

The debitage analysis was conducted using descriptive and classificatory methods the generally follow Andrefsky (2008). Two subcategories were assigned to the debitage; flake type, following Sullivan and Rosen (1985) as modified by Prentiss (1998) (shatter, complete, fragment, broken, split), and technology type, as defined by by Andrefsky (2001) (simple, bipolar, bifacial thinning, unifacial thinning, microblade, decortication, shatter, core fragment). These were used to parse apart stages of lithic reduction and identify specific industries.

Raw material analysis was conducted and types were based on visual examination of colour (both descriptive and Munsell), lithology, surface texture, light transmittance, grain size, cortex, and inclusions. Individual codes were assigned to identify types based on characteristics and notes were given on possible relationships between type (see Appendix D for raw material assignments). Shorthand codes were assigned based on initial interpretation of lithology (i.e. C = chert, B = basalt, etc). However, the codes remained the same for consistency after additional input on the rock type was collected (i.e. B2 was reassessed to be jasper, not basalt). The researcher assigned codes for quality of raw material (low, medium, high), judgementally based on lithology, grain size, and inferred knapping capability. Raw material groups are useful in determining if specific types were used in differing ways (Andrefsky 2008), and if variances occurred before or after the WRAn eruption indicating possible changes in procurement strategies or site use.

Debitage attributes recorded include:

- Cortex (0%=0, 1–49%=1, 50–99%=2, 100%=3)
- Cortex type, if possible (cobble or geological)
- Weight (to the nearest 0.01g)
- Length, width, thickness, for all flakes larger than 5mm (to the nearest 0.01mm)
- Size class were inferred for all debitage after measurements and recorded in increments of 5mm maximum dimensions (SC1 = 0–5 mm, SC2 = 5–10 mm, etc.)
- Thermal alteration, shown by evidence of heating, including pot-lid fractures, crazing, color changes (1=present, 0=absent)

Flakes with platforms present also had the following attributes recorded:

- Erailure scar, scars on the bulb of force (1=present, 0=absent)
- Lipping, lip on ventral platform edges (1=present, 0=absent)
- Bulb of force, relating to application of force (diffuse or salient)
- Platform preparation, modification of the platform prior to flake removal (simple, complex, cortical, abraded, crushed)
- Termination of complete flakes (feathered, hinge, overshot, step)
- Platform width and thickness (to the nearest 0.01mm)

Reductions stages can be inferred from platform preparation, flake sizes, presence or absence of cortex, and the type of raw material utilized. Variation in flake size could indicate a variety of behaviours. Thinner flakes tend to relate to tool production, whereas thicker flakes tend to relate to core reduction (Sullizan and Rozen 1985; Andrefsky 1998). In the same respect, larger size flakes generally relate to earlier stages of reduction, whereas smaller debitage relates to later stages. Under-representation of larger flakes could indicate preferential removal of blanks.

Debitage characteristics can also assist in inferring percussor type. Soft-hammer percussion is associated with smaller flakes, platform lipping, and fewer complete flakes. Hard-hammer percussion is associated with larger flakes, larger platforms, salient bulbs of force, erailure scars, and more complete flakes. Pressure flakes are associated with very small flakes, small platforms, and more complete flakes (Allan 2018). Bipolar reduction implies scarcity of high quality raw material and the need to utilize smaller cobbles for toolstone production. It is suggested this type of reduction is used when groups are more sedentary or under mobility constraints (Jeske and Lurie 1993).

Termination types can be helpful to guide conclusions on lithic behaviour. Feathered termination indicates a smooth/steady force and is generally desired during lithic reduction, hinge indicates the force rolling outward and is common on flatter surfaces, overshot indicates force rolling inward and is generally considered to reflect ‘mistakes’, and step termination indicates the force stopped on the core and was not given consistent pressure (Andrefsky 2008).

Heat damage can be expressed on lithics in a variety of ways including pot-lidding, colour variation, crazing, and fractures. This can happen for a number of reasons; however the two most common are accidental heating from throwing flakes into a hearth, or specific heating in hopes of improving the quality of the raw material (Domanski and Webb 1992; Mercieca and Hiscock 2008). It is also possible that heat damage could occur at multi-component sites due to exposure from overlaying hearths. Heat treatment would make certain raw materials possible or easier to knap and allow for finer control of tool production.

Presence of cortex among raw materials may relate to the proximity to the material source. In additional, differential use of certain raw materials or quality could indicate preferences for specific uses (expedient or curated tools). Large amounts of cortex, along with the presence of larger flakes, simple platforms, flake cores, shatter and hard hammer percussion together typically indicate on-site toolstone production and potentially locally obtained materials. On the other hand, non-local materials are generally more curated; therefore, less cortex, small flake sizes, more prepared platforms, less flake core portions, more soft-hammer and pressure flaking (Bamforth 1986). The entire sequence of tool production may be represented for local raw materials, while it is likely that nonlocal raw materials would be richer in late stage or resharpening debitage.

Site types could be reflected in the relationships between raw material types/quality and tool production/maintenance. In theory, longer-term occupation sites should include lower quality raw materials and *ad hoc* tool maintenance, whereas short-term, task specific sites should include multiple lithic sources, higher quality raw materials, more evidence of tool maintenance. It has been posited that tool formality and standardization, like bifacial and microblade industries, may reflect overall mobility due to their more efficient manufacture processes (Kelly 1988; Rasic 2011). However, the availability of raw material might also affect the toolstone production practices (Andrefsky 1994).

4.2.4.4 Spatial Control

As the site and artifacts were mapped in 2017 utilizing a Leica Builder 209 total station, it is possible to investigate distribution patterns of artifacts through the various components. It is also possible to broadly look at the amount of artifact types and features located in units throughout the site at specific intervals. The data was imported into *ArcGis Desktop* 10.6.1 and the distribution patterns were qualitatively analyzed.

The site was analyzed utilizing data from faunal specimens, lithic material, features, and total artifacts recovered from each component and also compared by pre/post the WRAn. This provided insight into possible changes or continuity over time and if behaviour pattern changes were gradual or abrupt. With the amount of excavation undertaken at the site, there is enough information to form preliminary conclusions and hypotheses that can be utilized as a basis for future investigations or comparative analysis.

4.2.5 Limitations

When analyzing collections acquired by multiple researchers, there can be a number of challenges. Inconsistencies in the ways in which information was collected, recorded, identified, or analyzed could present limitations on the data. The Forty Mile Site has seen three previous principal investigators including the 2017 excavation by myself. In addition, due to the number of times that the site had been visited, there are discrepancies between the ways in which information was gathered and recorded. One way this has been mitigated is the fact that the previous researchers continue to be available to ask questions and provide insight into their methodology and scope of work. At times, re-analysis was conducted in order to be able to compare data sets, in other cases trust was placed on the previous work and I adapted their systems in order to allow for data consistency.

It is also important to note that 36 years have passed since the first survey was conducted. Within this time there have been vast improvements to technology when it comes to mapping, curation of artifacts, and archaeological methods and analysis have been generated. While it is no fault of the previous research, there are indeed times when gaps of information are present, or the data does not necessarily coincide with the most recent excavation. One of these instances is the fact that faunal remains were not discussed in previous analysis of the site. While faunal remains were collected and catalogued, they were not considered artifacts during the overall site evaluation in unless they were worked or modified. For the overall site assessment all faunal remains are considered artifacts and will be analyzed.

The prehistoric component of the Forty Mile Site has seen considerable disturbance over the years, namely from the construction of a townsite that included buildings, ditches, roads, and graveyards, but also by natural factors such as erosion, fire, ice rafting, and flooding. All of these factors present a challenge to the analysis of the prehistoric component due to the inability to confirm stratigraphic provenience at times. However, as with all archaeological investigations, it is rarely possible to have a fully intact, undisturbed site. It is this limitation that also presents a challenge to overcome for the researcher and to acquire as much information as possible and analyze the data to the best of our ability in order to interpret the culture of the past.

Chapter 5: RESULTS

The first section of this chapter discusses the results of the analysis conducted on the 6-Mile Lake pollen core. This includes the age model, percent and concentration diagram, and the influx diagram. The following section reviews the archaeological excavation conducted at the Forty Mile Site (LcVn-2). Results are presented for the stratigraphy and chronology of the site. The results of the spatial distribution of the 2017 excavation are presented along with overall statements about the site. The outcomes of the faunal analysis are then presented, followed by the lithic assemblage.

5.1 THE 6-MILE LAKE POLLEN CORE

This section summarizes the results of the analysis conducted on the pollen core and is divided into the following subsections: 5.1.1 provides the results of the radiocarbon dating and details the age model creation and outcomes; 5.1.2 outlines the results of the percent and concentration data of the pollen analysis and 5.1.3 details the results of the influx diagram compiled from the pollen analysis.

5.1.1 AGE MODEL

The age model for the lake core was created using the samples sent for radiocarbon analysis, in addition to the dates acquired previously from the lower drives (Table 5.1). Of the five samples submitted in 2017, four returned with dates and the fifth sample was undateable. Of the four dates, one was excluded from the analysis as it was considered an outlier (sample UGAMS33332). The outlier dated ~400 yrs older than the sample date located 31 cm further down, and it was older than both the previously accepted WRAn age of 1830 cal BP (Lerbekmo et al. 1975) and the recent published date of 1625 cal BP (Reuther et al. 2019). The previous dates acquired in 2014 also held a spurious date that was excluded from the analysis (Bigelow 2014). Outliers can occur for a number of reasons including old carbon integrated in the samples from aquatic plants, reworking of the lake sediments over time, human error, or contamination during collection, analysis, or processing. Integrated old carbon creates a reservoir effect. This causes aquatic vegetation, because it is using carbon from the water, to have ^{14}C ages older than actual deposition time (Abbott and Stafford 1996). Age models were generated both with and without the spurious dates in order to confirm that they were indeed outliers. As the outcomes would affect the results of the age model, these outliers were excluded from the age model; however, they are still displayed on the graph in order to provide context.

Table 5.1 Radiocarbon dates from 6-Mile Lake, results from Bigelow (2014) and 2017 combined.

Lab ID	Year	Material	14C age yr BP	±	Calibrated Age (median)	Core depth	Total Core Depth
UGAMS33332	2017	Plant frags	2490[1]	25	2604	Surface 68–70 cm	57–59 cm
UGAMS32636	2017	Pollen	2090	25	2060	D1 13–15 cm	88–90 cm
UGAMS32637	2017	Pollen	n/a	-		D1 20.5–22.5 cm	95.5–97.5 cm
UGAMS32638	2017	Pollen + plant fragments	2630	30	2757	D1 29–30 cm	104–105 cm
UGAMS32639	2017	Pollen + plant fragments	3400	30	3642	D1 79–81 cm	154–156 cm
OS-106818	2014	Herbaceous fragments	5580	30	6358	D2 69–70 cm	240–241 cm
OS-106642	2014	Moss	6690	40	7561	D3 36–37 cm	300–301 cm
OS-106615	2014	Wood	8780	45	9795	D3 83–85 cm	348–350 cm
OS-106819	2014	Moss + herbaceous fragments	8870	35	10023	D3 83–85 cm	348–350 cm
OS-106820	2014	Eleocharis seed +leaves	9170	35	10326	D4 10–12 cm	369–371 cm
OS-89855	2014	Seeds + graminoid leaf fragments	12300[1]	50	14224	D4 19–20 cm	378–379 cm
OS-89982	2014	Terrestrial leaves and seeds	9430	45	10662	D4 46–47 cm	405–406 cm

[1] These dates were not used in the chronology (explanation in text).

The chronology for the core was then constructed using all accepted dates. The sediment-water interface was set to -60±5 yr BP because the radiocarbon age scale begins at AD 1950 and the lake was cored in 2010. The WRAn age was not proscribed when generating the age model. A second order polynomial regression with a 95% confidence interval was chosen as it seemed to best fit the radiocarbon dates. Figure 5.1 shows the results of the depth-age plot that was used to construct the age model.

After completing the plot, it was realized that the modeled age of the WRAn was 2367 cal BP, which is 480 years older than the previously accepted mean uncalibrated date of 1887 BP (Lerbekmo et al. 1975) and 742 years older than the newly published date of 1625 cal BP (Reuther et al. 2019). As a result, it became suspect that the core, or at least sections of the core, were dating older than expected. In particular, the samples of *Picea* pollen that bracket the WRAn could have included small particulates of aquatics, which often results in older dates due to reservoir effects (Abbot and Stafford 1996).

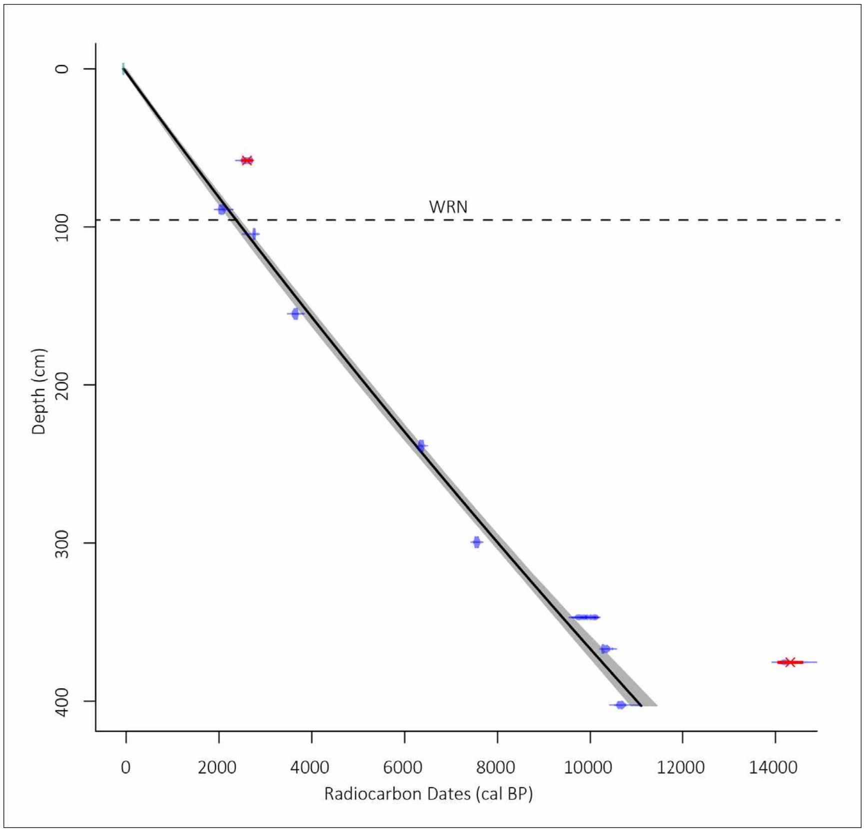


Figure 5.1 Age model for 6-Mile Lake core 10C. Note: The x-axis are cal yr BP, the y-axis is depth in the core. The outliers are plotted and coloured in red and the WRAn is indicated by the dashed line.

However, all accepted dates occurred in stratigraphic order and lie within relative proximity to the modeled ages, which suggests that the lake sediment deposition was relatively uniform and unlikely to have gaps. As a result, it is reasonable to utilize the age model to calculate the sedimentation rate in the pollen diagrams. In total, 85 yrs pre-ash and 68 yrs post-ash were analyzed. This produced a 26 yrs/cm sedimentation rate for this section of the core, not including the WRAn; therefore, the time difference between samples was 6.5 years per 2.5 mm. This rate was constant in this portion due to the fact that it was such a close interval analysis and all the samples were located between two radiocarbon dates of the age model.

5.1.2 Percent and Concentration Data

The percent and concentration data are presented in the summary diagram (Figure 5.2). This first portion of the diagram provides the relative abundance of the various types of pollen that were identified in the sample slides. The second portion of the diagram displays the concentration of grains per cm^3 in the samples. The horizontal lines represent the individual samples, five below the tephra spanning ~85 yrs and 11 above the tephra spanning ~70 yrs. The light grey shading signifies 5x exaggeration and was added to taxa with low counts in order to more easily visualize pollen presence and trends. The dark grey shading signifies 10x exaggeration and was added to the concentration of the herbs and forbs colour in order to display the similar trend occurring as the trees and shrubs. The entire pollen analysis was comprised of 7.25 cm of sediment, which included the 1 cm section of WRAn.

The percent data provide the opportunity to look at the presence and proportion of the various pollen taxa identified in each sample. While the percent data isn't a perfect match for the vegetation that existed on the landscape, it provides the opportunity to look at which species were identified in the slides and the occurrence of each taxa. The dominant pollen taxa include *Picea* (spruce), *Betula* (birch), and *Alnus* (alder), and the consistent presence of *Salix* (willow), *Populus* (cottonwood or aspen), *Cyperaceae* (sedges), *Poaceae* (grasses), as well as an assortment of herbs and forbs. Boreal forest taxa are present throughout, without obvious changes, at least in the percent data in the samples both above and below the tephra.

The concentration portion of the diagram displays two spikes in grains per cm^3 after the ash, which is mirrored in both the trees and shrubs, and the herbs and forbs once they have been exaggerated. These spikes occur ~15 and ~30 years post-ash deposition. The first spike increases the concentration by more than 2x the previous sample, similarly the second spike contains 2x the concentration than the succeeding sample. The taxa driving the initial spike at ~15 years for trees and shrubs (in order of abundance) include *Alnus* (alder), *Betula* (birch), *Picea* (spruce), and *Populus* (cottonwood or aspen). For the herbs and forbes, the taxa include high amounts of both *Poaceae* (grasses) and *Cyperaceae* (sedges) in approximately equal amounts. The taxa driving the second spike at ~30 years for trees and shrubs (in order of abundance) include *Betula* (birch), *Picea* (spruce), *Alnus* (alder), and *Salix* (willow). For the herbs and forbes the taxa include *Cyperaceae* (sedges) and *Poaceae* (grasses), occurring at a 4:1 ratio. This tells us that there are more pollen grains, and potentially plants, occurring in the surrounding ecosystem. The concentration diagram also removes the issues of percent data, including the zero-sum problem in the percentages. The data in this diagram are not adjusted to include the sedimentation rate

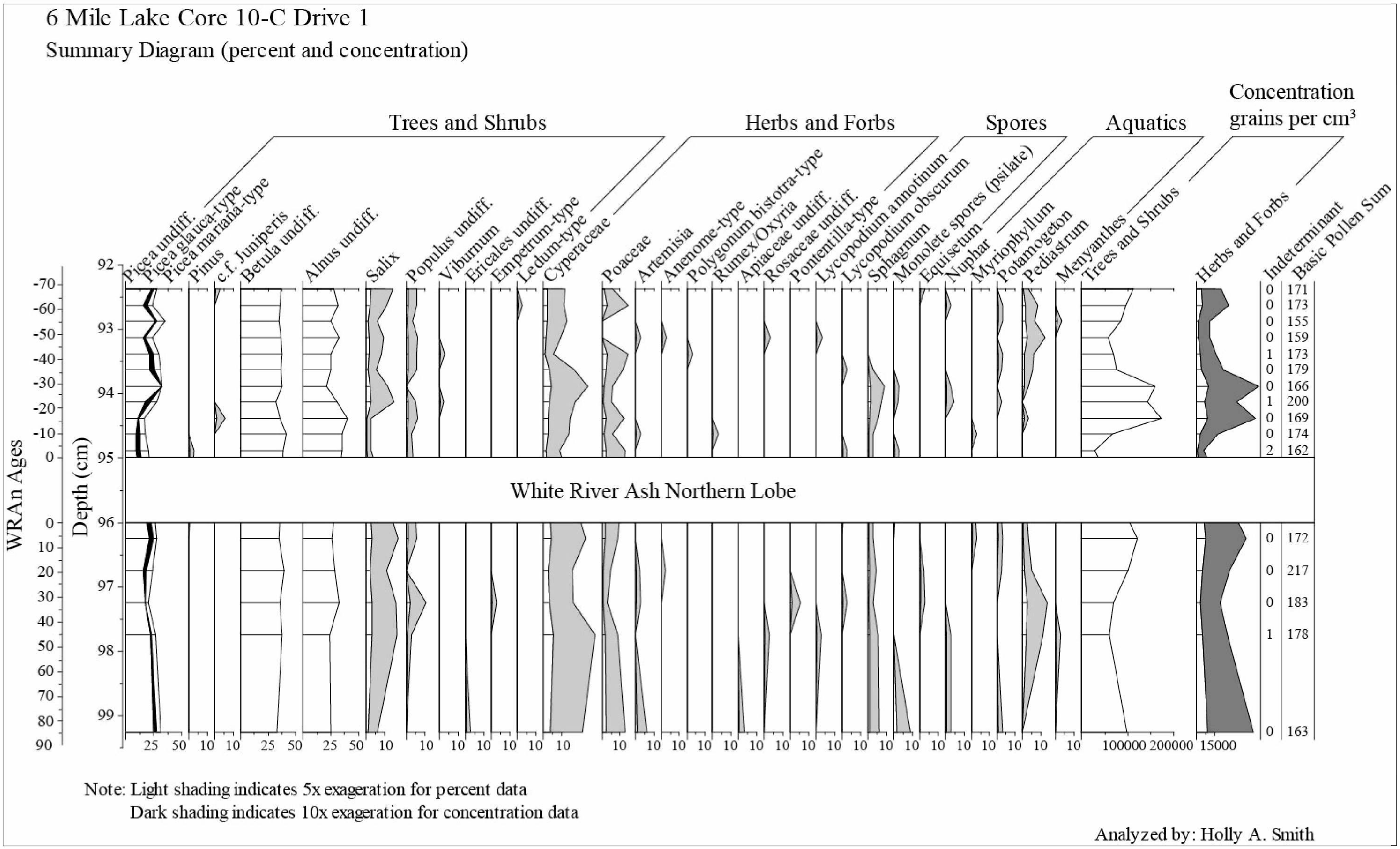


Figure 5.2 Summary pollen diagram of the percent and concentration data from 6-Mile Lake.

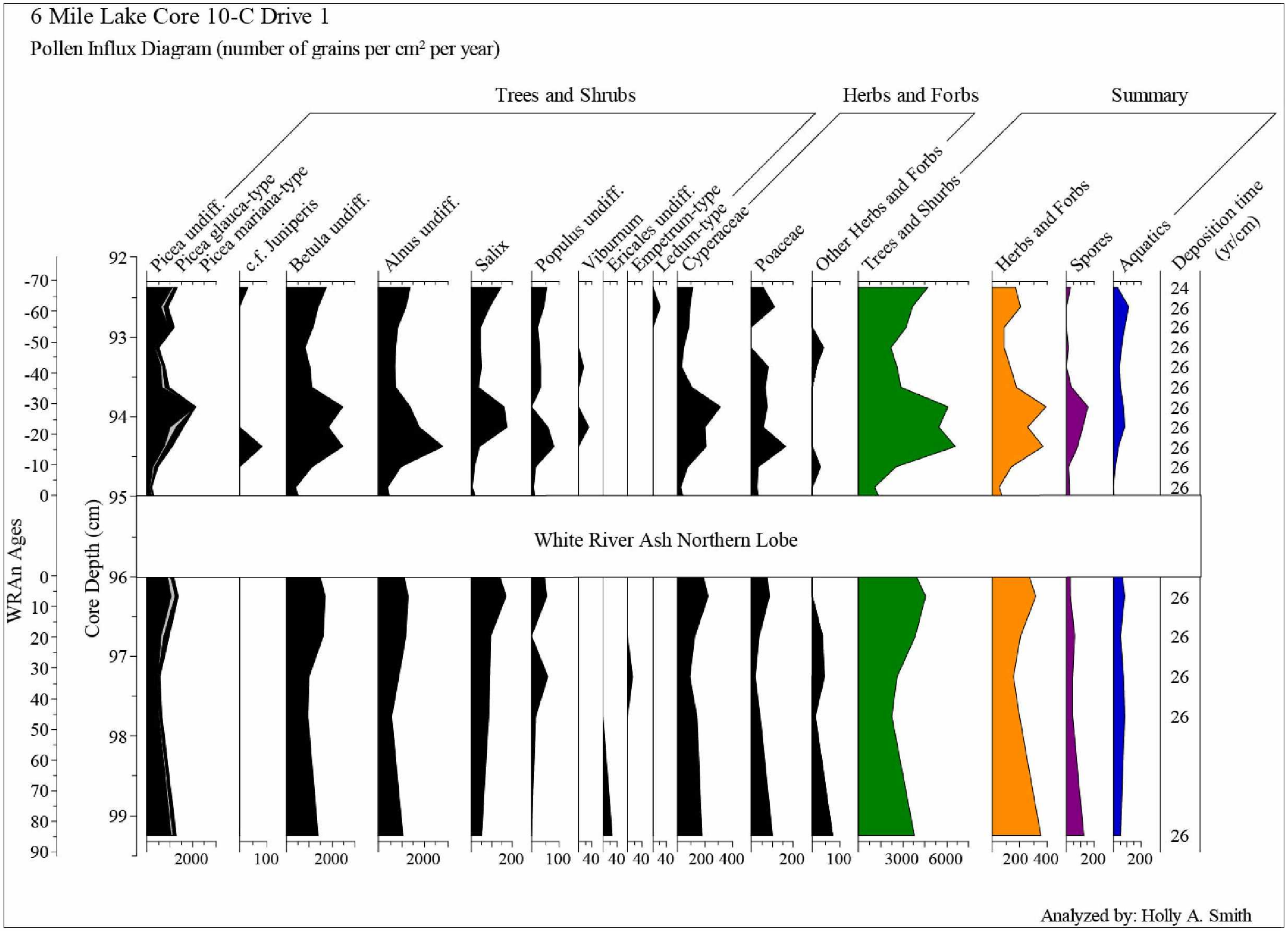


Figure 5.3 Pollen influx (grains/cm^2/yr) at 6-Mile Lake.

from the age model, though they do provide insight into which taxa were present in the landscape and the abundance of grains in the samples.

5.1.3 INFLUX DATA

The influx diagram (Figure 5.3) synthesizes a great deal of information encompassing all the pollen data acquired throughout the study, and makes it possible to identify changes occurring following the WRAn tephra deposition. There is an obvious trend in the summary data occurring for all four of the major flora groupings, each appears to be mirroring similar influx rates within the sampled section of the core. While there are slight differences, the overall trend appears consistent. There were fairly stable levels of pollen occurring prior to the WRAn eruption in terms of abundance and types of taxa present. These baseline pre-WRAn eruption pollen samples then decrease significantly in abundance following the tephra fall and succeeding ~5 years, and then a significant increase, producing a double peak ~15 and 30 yrs after the eruption before returning to similar pre-eruptive levels at ~35 years (Table 5.2).

Table 5.2 Influx values for pollen at specific intervals.

Approximate Timeline	Description	Trees and Shrubs	Herbs and Forbs	Basic Pollen Sum
Pre-ash	Average influx of 5 baseline samples	3426	244	3670
5 years post-ash	Initial response to tephra	1060	48	1107
15 years post-ash	Increase in productivity (1st spike)	6605	372	6977
30 years post-ash	Increase in productivity (2nd spike)	6101	391	6492
35 years post-ash	Return to comparable pre-ash rates	2907	172	3079

The influx summary graph appears comparable to the concentration data presented in the summary diagram, as the sedimentation rate determined by the age model was consistent. The pollen timeline presented is a mere 155 years within 7.25 cm of the lake core and influx alterations did not occur within this section of the core. At ~15 yrs post-eruption there is an increase in pollen abundance of *Poaceae* (grasses) and other herbaceous taxa, as well as *Betula* (birch) and *Alnus* (alder). Other contributors include *Populus* (cottonwood or aspen). A second wave of pollen productivity at ~30 yrs post-tephra deposition is driven by the *Cyperaceae* (sedges), *Picea* (spruce), again with *Betula* (birch) pollen grains, as well as *Salix* (willow). These increases in pollen abundance occur at almost 2x the pre-ash values, and approximately a 6x increase from the initial post-ash sample.

While there are a number of additional species that contribute to these influx patterns, the main drivers are wind-pollinated species of trees and shrubs. *Alnus* (alder) and *Populus* (cottonwood or aspen) spike only in the 1st peak, whereas *Picea* (spruce) spikes only in the 2nd peak. It is also relevant to note that while the other taxa increase and decrease, *Betula* (birch) is the only species that increases during both spikes.

5.2 Forty Mile Site (LcVn-2) Excavations

During the 2017 excavation, four 2x1 m blocks were completed at the Anglican Church and Mission (ACM) locality (Figure 5.4), totalling eight square meters. Past excavations at the site included a total of 92 shovel tests and 35 1x1 m test units, bringing the total 1x1 m units to 43, with only nine of these units and two shovel tests excavated beyond the WRAn. The goal was to expand out from the units excavated in 2003, which were located parallel to the north wall of the historic ACM. Efforts were made to re-establish the grid based off of field reports and mapping prepared prior to stabilization of the building. Unfortunately, it was discovered early in the excavation that during the stabilization of the building, the entire building was not merely lifted, but also shifted north ~30 cm and ~40 cm west. It was also noted that during this building maintenance a fair amount of ground disturbance was inflicted on the top 40 cm of soil to the east of the building, impacting Block 3. These issues were dealt with in the field and recorded in an effort to delineate the differences between the artifacts recovered in situ and those found in secondary context.

This section summarizes the results of the excavation and analysis conducted at the Forty Mile Site in 2017 and is divided into the following subsections: 5.2.1 provides the results of the stratigraphic record and radiocarbon dating; 5.2.2 provides the results of the spatial analysis of the excavation; 5.2.3 provides the results of the faunal analysis conducted; 5.2.4 details the results of the lithic and artifact analysis and implications of the results.

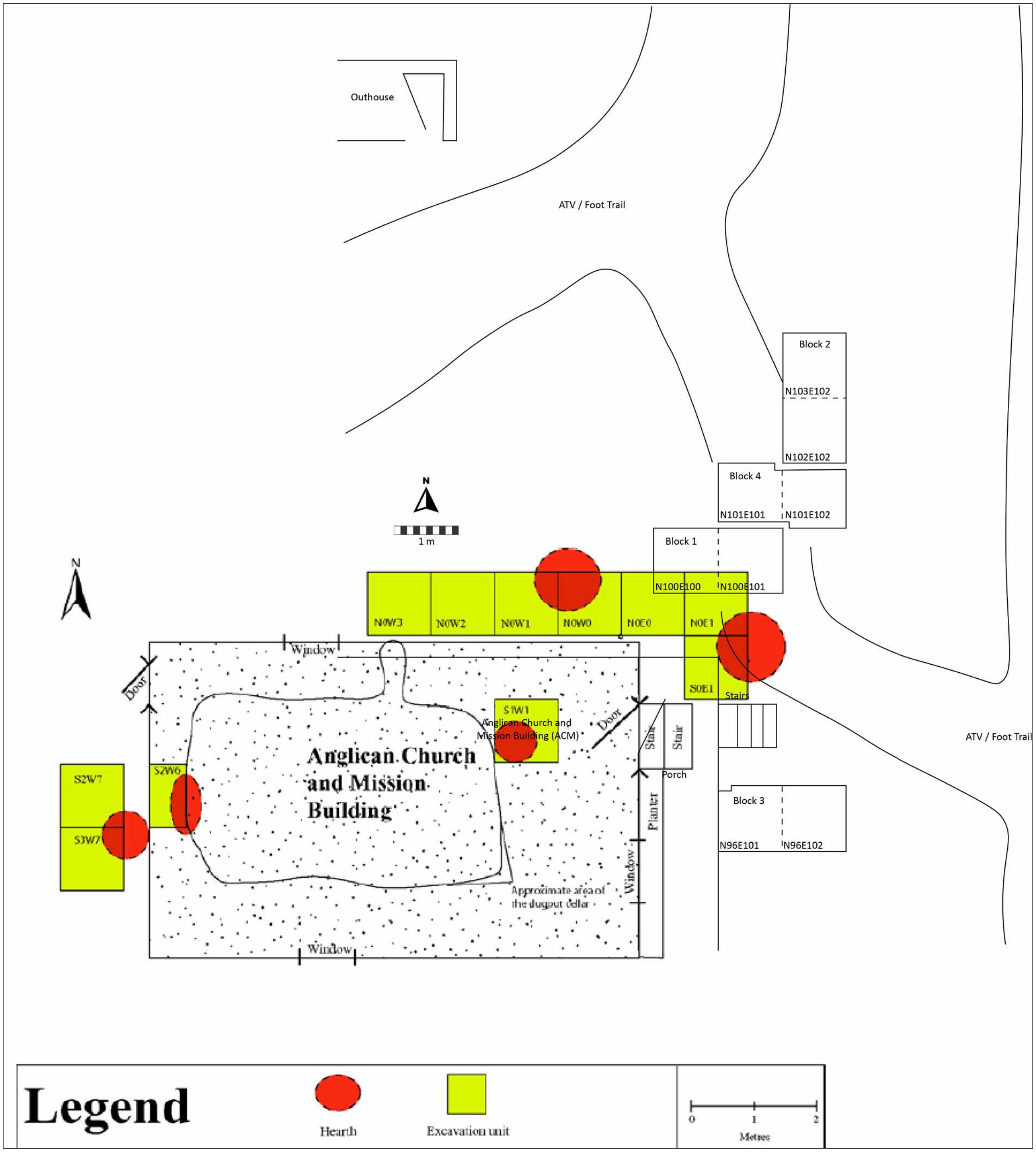


Figure 5.4 Site map from 2017 excavation combined with previous work (adapted from Thomas 2004).

5.2.1 Stratigraphy and Site Chronology

The stratigraphy of the site is a complex layering of light brown silts with varying amounts of sand and dark organic stained silts (Figure 5.5). Chunks of charcoal were prevalent throughout the sediments and river cobbles with sand pockets occuring in clusters throughout the stratigraphic column, likely from ice rafting and flooding episodes. An approximate 1 cm thick band of WRAn tephra is present at approximately 80 cmbs, mostly intact throughout the excavation units. The six cultural components identified during the previous excavations were all present; two occupations predate the WRAn ash fall and four components occur after the eruption (three of these were prehistoric, and one contained historic and proto-historic material). The excavation units were excavated down to ~120 cmbs in each block. The goal was to acquire as much material as possible from the previously identified cultural levels beneath the WRAn. Due to time restrictions, the blocks were not excavated to the lowest depths. Before backfilling, the blocks were lined with thick sheets of plastic in order to assist in continuing the excavation in the future. The excavation terminus consisted of light brown silty sands overlain with dark organic silts, which contained cultural Component 6.

The stratigraphy of the site displays a rich cultural history of continued land use not only at the ACM locality, but throughout the entire Forty Mile Site. Evidence of human occupation through archaeological material is present both prior to and following the WRAn tephra. While this persistence is recognizable stratigraphically, it does not necessarily represent continuous occupation without relatively short periods of disuse (short-term hiatuses). As previously acknowledged, occurrences of flooding, erosion, and natural disturbances that occur due to varying water levels at a confluence of two sizeable rivers could both add (deposit and accumulate) and take away (erode) sediment to varying degrees. This modification of the landscape makes it necessary to thoroughly investigate the chronological sequence in order to make solid conclusions about the cultural components identified at the site.

Of the eight samples sent to the lab for radiocarbon dating, only four were successful in generating radiocarbon dates. All the bone samples, save for one, had insufficient collagen to run the analysis. The date associated with the one bone sample that had sufficient collagen was assessed as being spurious due to the fact that it was reported as older than the WRAn, even though it was located ~50 cm above it. The newly acquired dates were compiled along with the previously attained samples and were collectively run through the calibration software Calib 7.0.4 (Table 5.3, Figure 5.6, Figure 5.7) Full calibration reports are in Appendix E. This analysis produced a more complete chronology of the site. The calibration shows that while there does appear to be a slight gap in the cultural occupation of the site between Components 4 and 5, the absence likely occurred before the tephra deposition and not as a result of it. The two reported median calibrated dates for Component 4 were 1477 cal BP and 1632 cal BP. This

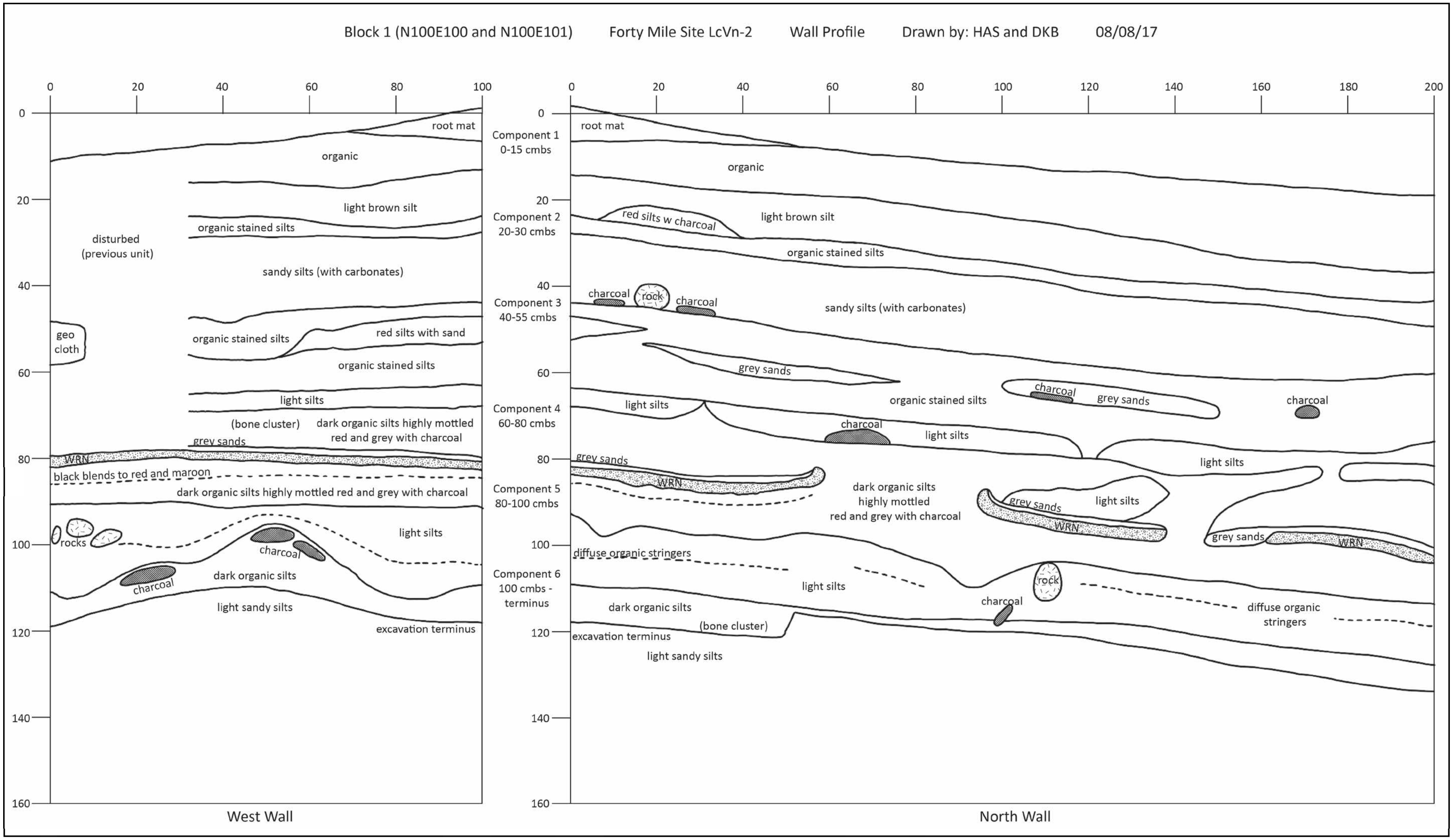


Figure 5.5 Block 1 stratigraphic profile displaying occurrences of cultural components.

information along with the median calibrated date for the WRAn of 1625 cal BP (Reuther et al. 2019), produce the possibility that people were present at the site relatively soon after, if not directly following, the volcanic eruption.

Table 5.3 Radiocarbon dates for the Forty Mile Site. Calibrated dates (2-sigma) were produced using IntCal13 terrestrial calibration curve in software Calib 7.0.4 (Reimer at al. 2013, Stuiver et al. 2013).

Lab ID	Year Tested	Locality and Component	Material	14C age (yrs BP)	±	Depth (cmbs)	Calibrated Date (cal BP)
WK-328381	2011	ACM - Component 2	Charcoal	68[1]	26	25–30 cm	-
UOC-5645	2017	ACM – Component 2	Bone	1801[1]	25	25–35 cm	-
WK-32837	2011	ACM – Component 2	Charcoal	592	25	35–40 cm	540–650
UOC-5647	2017	ACM – Component 3	Charcoal	1119	24	50–55 cm	960–1070
Beta-366149	2013	ACM – Component 4	Charcoal	1590	30	65–70 cm	1410–1550
UOC-6203	2017	ACM – Component 4	Charcoal	1724	26	60–70 cm	1560–1700
Beta-185976	2003	ACM – Component 5 (large side-notched biface)	Charcoal	2330	40	~90 cm	2180–2480
UOC-5650	2017	ACM – Component 5	Charcoal	2262	23	105–110 cm	2160–2350
Beta-185977	2003	ACM – Component 6 (small side-notched biface)	Charcoal	2230	40	100–115 cm	2150–2340

[1] These dates were not used in the chronology (explanation in text).

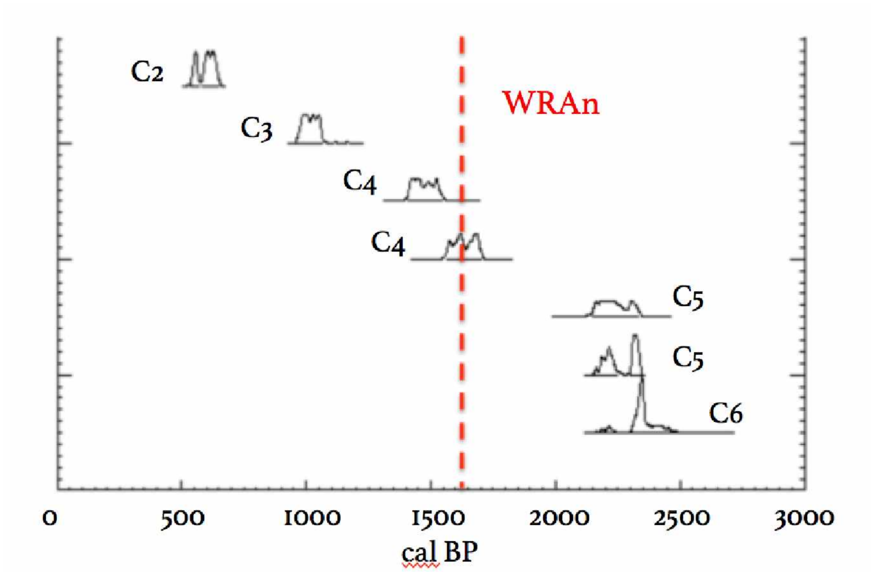


Figure 5.6 Calibrated age ranges for the Forty Mile Site cultural components. Vertical axis is the cultural component of the site (reference Figure 5.5), the horizontal axis is the 2-sgma calibrated age range. For sample information, see Table 5.3.

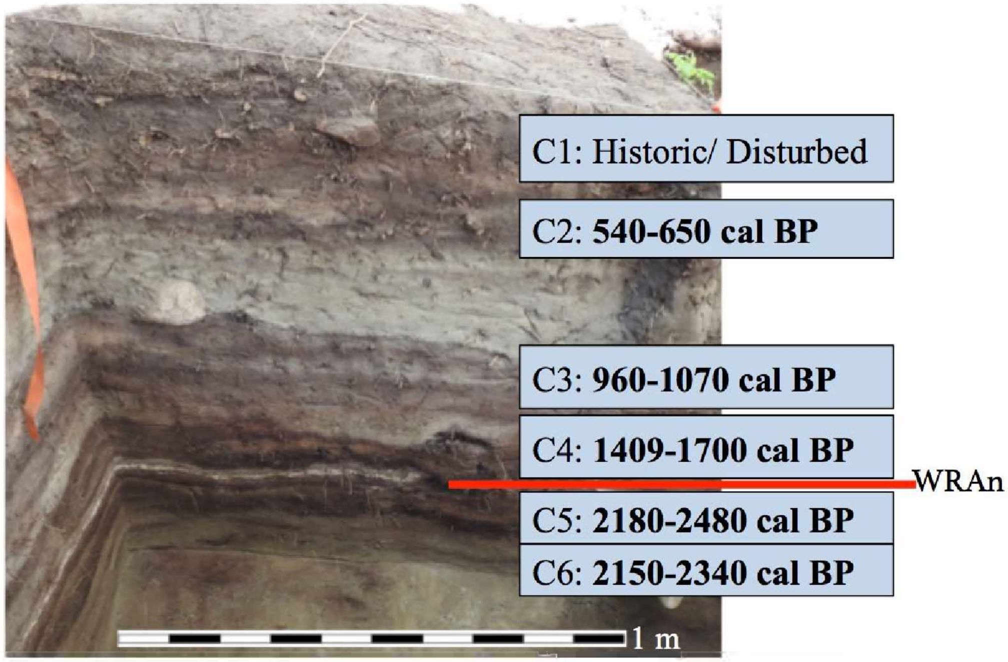


Figure 5.7 Block 1 West wall stratigraphy, with location of WRAn and cultural components identified at the Forty Mile Site. For radiocarbon sample information, see Table 5.3.

5.2.2 Spatial Distribution

The focus of the project is on the pre-contact components, which were located below ~20 cmbs, and all potential artifacts were recorded with the total station. Artifacts, features, and disturbances that were recovered with 3-point data were mapped and spatial data are presented in Figure 5.8. Artifacts found in screens were recorded and added to the overall counts for context in Table 5.4. Historic artifacts recovered in the top ~20 cm were collected and recorded by unit and quad.

Table 5.4 Artifact counts for the 2017 excavation.

	Cultural Components					
	Post-Ash				Pre-Ash	
Artifact Types	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**
FCR	59	4	2	1	3	49
Birch Bark	0	0	0	0	2	1
Bone	434	40	160	923	447	78
Charcoal	1	2	6	0	0	2
Lithic	112	8	31	3	635	313
Rock	1	0	3	0	0	0
Total	**607**	**54**	**202**	**927**	**1087**	**443**

Component 1 and the disturbed areas consisted of mostly out of context material and included high amounts of historical specimens. These historical specimens included glass, nails, ceramics, bullet casings, plastic, buttons, hinges, wood fragments, wallpaper, fabric, etc. These definitively historic objects were not recorded with the total station. A high amount of bone, lithic debitage, and fire cracked rock (FCR), were also incorporated within these levels and were recorded when encountered. It is unknown for certain to what extent these materials were re-worked or disturbed.

Component 2 consisted of a small collection of bones (n=40), a possible hearth feature in Block 2, and a small amount of lithic debitage (n=8) and charcoal (n=2). The fire-reddened soils of a possible hearth feature did not contain any artifacts, but did have a lithic flake nearby. Unfortunately Block 3 was entirely disturbed for this component and did not yield any cultural materials in primary context even though the component was likely originally present in this area.

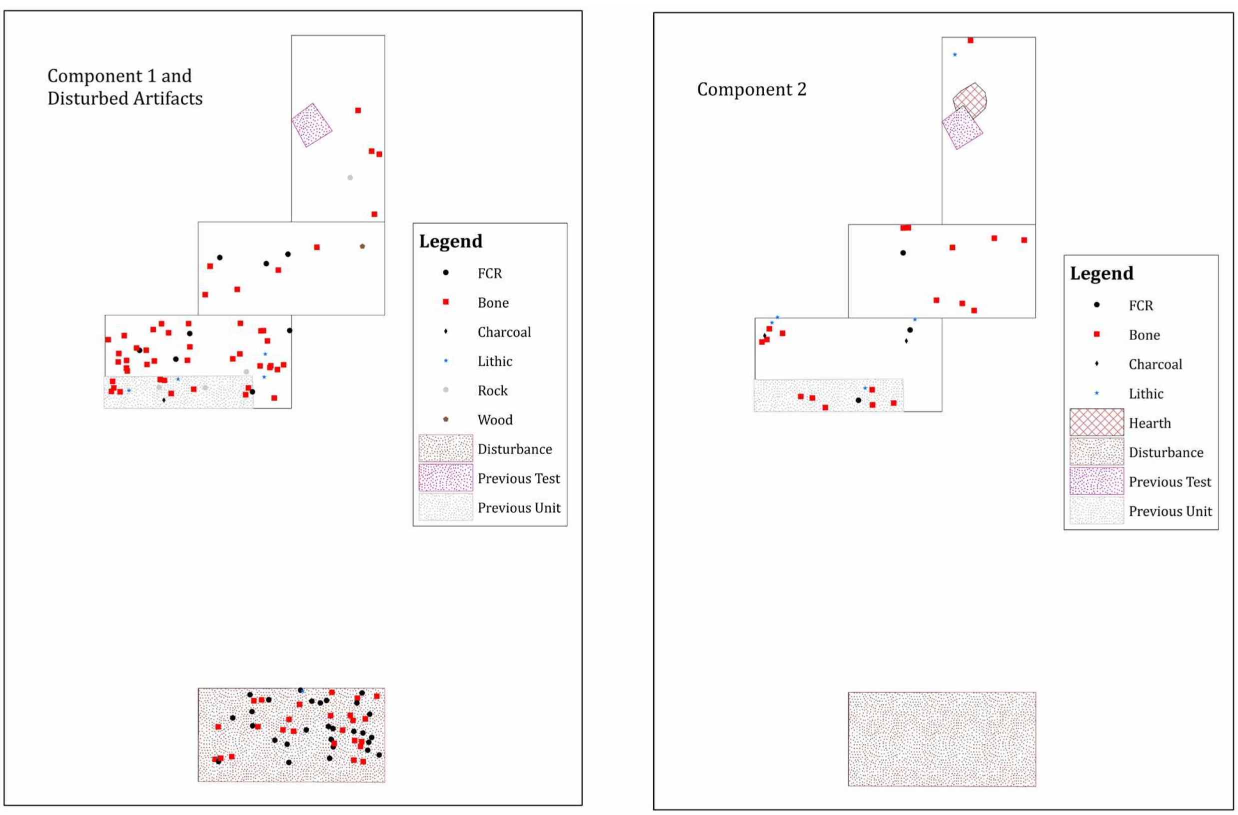


Figure 5.8 Spatial distribution of 2017 excavation by cultural component, including artifacts, features and disturbances.

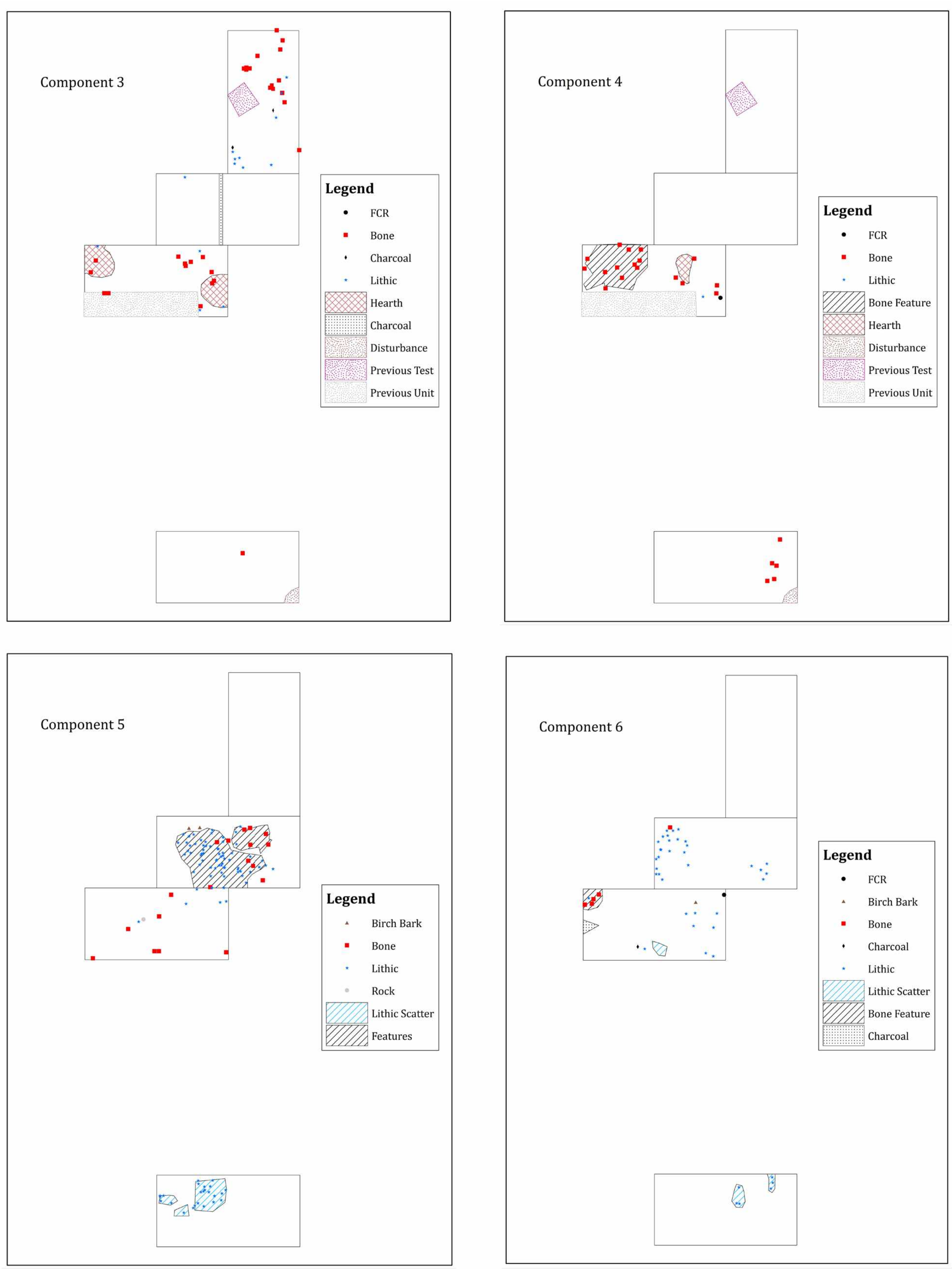


Figure 5.8 Spatial distribution of 2017 excavation by cultural component, including artifacts, features and disturbances. *Continued from previous page*

Component 3 consisted of two possible hearth features, bone (n=160), lithic debitage (n=30), and a charcoal feature. Both hearth features had bone recovered within and surrounding them. There was an area in Block 2 with an assemblage of lithic debitage, which could be evidence of a tool processing area.

Component 4 was absent in both Blocks 2 and 4; however, Block 1 produced a large bone feature and possible hearth. The total bone in this component consisted of 923 fragments and likely extends to the north beyond the excavation limits. This feature could have been a discard area or a location of bone processing. In addition, a small possible hearth feature was located within 20 cm to the east within the same block. The bone feature and hearth were notable because they extended almost to the WRAn tephra layer, with very little sediment (<1 cm in some locations) separating the tephra from the feature. The bones that were identifiable from this component included 12 fragments of a moose maxilla (refit), a sternum of a cf. grouse, and a mandible of a small rodent. On the other hand, very few lithic fragments were uncovered in this component (n=3), indicating the area was utilized for food processing or as a discard zone. Lithic maintenance may have occurred at this time as well; however, was not visible in the blocks excavated at this component.

Component 5 was the last cultural component that occurred before the fall of the WRAn. This assemblage consisted of the highest concentration of lithic debitage in the entire excavation (n=635). A fully intact large side-notched biface was recovered from this component during excavations in 2003; it is made of high-quality chert and measures 97 mm in length. As seen in Figure 5.8, this level contained a high lithic concentration in Block 3 that appeared to be clustered in three localities. There was also a lithic and bone feature in Block 4, which could have possibly been a hearth feature, or activity area. The soils here were not reddened as per a typical hearth feature; however, it did contain slightly darker organics than the surrounding soils. This component also had two pieces of birch bark recovered in close proximity to the features in Block 4.

Component 6 also contained high lithic concentrations of lithics (n=313), located in three out of the four blocks. There was also a portion of a bone feature recovered in Block 1 in close proximity to a charcoal concentration. Both of these were only partially located within the block indicating the features extend well beyond the current limits of the excavation. This component also uncovered a piece of birch bark and the only lithic tool uncovered during the 2017 excavation.

The rudimentary scraper was made of slice of metamorphosed siltstone with ~25% cortex, and likely created from a river cobble found along the river. It is inversely retouched and measures 118 x 84 x 20 mm and weighs 295 g. Based on the large size and weight of the scraper, it was likely created opportunistically and discarded after use. A short triangular side notched projectile point with a broken tip, made of siltstone was previously recovered in this level.

5.2.3 Formal Tools and Other Artifacts

The formal tools uncovered at the site encompassing all excavations total 8 scrapers, 12 utilized or modified flakes, 2 projectile points and 2 bone tools (Table 5.5) (Hammer 2002; Thomas 2003; 2004). While there isn't an abundance of formal tools, it is important to identify what was present in order to discuss them in the framework of the technologies established for the Taye Lake phase (Northern Archaic Tradition) and Late Prehistoric Period.

Table 5.5 All formal tools and artifact types recovered from the Forty Mile Site.

Artifact Type	Post-Ash	Pre-Ash
Bone tools	3	1
Scrapers	5	3
Retouched & utilized flakes	10	2
Projectile points		2
Birch Bark	20	3
FCR[1]	66	52
Debitage[1]	154	948
Faunal Specimens[1]	1557	525

[1] indicates only 2017 collections were tallied

Pre-ash tools include a single bone tool, 3 scrapers, 2 retouched or utilized flakes, and 2 projectile points. Post-ash includes 3 bone tools, 5 scrapers, 10 retouched or utilized flakes and no projectile points. These numbers must be considered in the context that there was a total of 43 1 x 1 m units excavated with only 9 of them excavated below the WRAn. In addition, there have been 4 cultural occupations identified post-ash and only 2 identified pre-ash. This bias in the sampling and comparison is relevant to note in terms of framing the analysis and identifying the limitations of the data.

While the sample sizes of artifacts and specimens recovered are small, some early deductions from the entire site are an increase in bone tools, and fewer projectile points recovered over time. Scrapers and utilized flakes are more abundant post-ash as well; however, this could possibly reflect the sampling bias as the debitage numbers from the 2017 excavation show significantly more lithic debitage in the pre-ash levels. During the 2017 excavation, three pieces of birch bark were recovered pre-ash, whereas in previous excavations 20 pieces were recovered all post-ash, including some pieces with puncture holes.

Based on the 2017 excavation results, which contain an equal number of units pre- and post-ash, there is an increase of fire-cracked rock at the site, a reduction in lithic debitage, and an increase in faunal specimens, which is consistent with Late Prehistoric Period sites.

5.2.4 Faunal Analysis

The majority of the faunal material recovered at the site in 2017 comprises highly fragmented unidentifiable specimens. Of the total 2082 fragments catalogued, 1628 (78%) were attributed to the pre-contact components (cultural Components 2 thru 6), and of those specimens, only 31 (2%) could be confidently identified confidently to size class. In order to create a more robust dataset, the fauna from the 2017 excavation was combined with the prehistoric faunal collections from previous work at the ACM locality (1180 specimens) and the North locality (1060 specimens). As the two localities were occupied simultaneously, analyzing them collectively should provide an understanding of resource gathering for the entire landform through time. As discussed in the above section, it is possible that the two loci were utilized during different seasons or for various resource gathering needs; however, by collectively assessing the assemblage, it is possible to see human responses to the local ecology over time regardless of season. Given the research questions and the size of the data set, it was most valuable to combine the datasets and analyze the collections based on components located above and below the WRAn ashfall.

In order to properly integrate specimens from previous excavations, a reanalysis was necessary due inconsistent analysis techniques, limited comparative collections available to the researchers, terminology, and database structure. This reanalysis included 1180 faunal specimens from the ACM locality, and 1060 from the North locality at the confluence. These additions brought the total faunal pre-contact collection to 3,868 specimens; 1,359 of which were from the pre-ashfall Components 5 and 6, and 2,509 from the post-tephra Components 2 through 4. This resulted in an additional 174 faunal artifacts that were identifiable to size class; 25 from the ACM locus and 149 from the North locus. Specimens from the historic component, generally consisting of artifacts located from excavated levels 0–20 cmbs, and were excluded.

5.2.4.1 Size Class and Identifiable Fauna

In total, 91.0% of the post-ash specimens and 99.6% of the pre-ash specimens were unidentifiable to size class or taxon (Table 5.6). The highly fragmented nature of this collection could be due to a number of reasons. Two of the most likely explanations are the fact that hunter-gatherers in this region used animal bone for tool manufacture, and also processed bones in order to obtain marrow and grease to supplement their diet (McClellan 1975). Larger animals tend to be the target of additional processing (Klein 1989), such as breaking in order to fit a certain pot size. It has also been argued that the larger surface area of a bone, the more susceptible it is to post-deposition destruction (Yeshurun et al. 2007). This could be from trampling or natural fragmentation. Smaller bones fragmented to the same size could still retain identifiable features, "for example if all bones have been reduced to ~2 cm fragments" (Clark 2017:56). While not all fragmented bones in the collection were individually measured, the average length of measured bones in the faunal analysis was 2.5 cm.

Table 5.6 Size class NISP and percentage for the entire Forty Mile faunal assemblage.

	Post-Ash		Pre-Ash	
Size Class	**NISP**	**%**	**NISP**	**%**
Very Small	1	0.7%	0	0.0%
Small	27	18.5%	1	20.0%
Medium	30	20.5%	1	20.0%
Large	32	21.9%	3	60.0%
Very Large	30	20.5%	0	0.0%
Fish[1]	7	4.8%	0	0.0%
Bird	19	13.0%	0	0.0%
Total	146	100.0%	5	100%

[1] Only bones were considered, scales not included.

While the collection sample was too small to apply utility indices such as grease (Binford 1978), marrow (Morin 2007), or dried meat (Friesen 2001), the high level of fragmentation at the site both above and below the tephra displays a form of consistency within the data. The most useful means of analysis was to identify the number of identifiable specimens (NISP) to size class, and if possible, to taxon (Table 5.7), and then explore their implications along with the taphonomic variables. Based on the research objectives, it is expected that certain species would be present in reduced amounts post-ash based on their diet, and that hunter-gatherers occupying the site post-eruption would adopt a broader diet breath which would be reflected in a wider variety of species in the faunal assemblage.

Table 5.7 NISP from faunal assemblage.

Taxon or Family	Common name	Size class	Post-Ash NISP	Pre-Ash NISP
MAMMALS				
Lepus americanus	Snowshoe Hare	Medium	6	1
cf. *Castor canadensis*	cf. Beaver	Medium	3	
Ondatra zibethicus	Muskrat	Medium	1	
cf. *Spermophilus parryii*	cf. Arctic Ground Squirrel	Small	1	
Rodentia	Rodents	Small	5	1
Canis lupus	Wolf	Medium	1	
Martes americana	American Marten	Medium	4	
Neovison vison	American Mink	Small	1	
Alces alces	Moose	Very Large	29	
Rangifer tarandus	Caribou	Large	25	2
Artiodactyla	Sheep/Caribou	Large	2	1
		Total Mammals	78	5
BIRDS				
Gavia	Loon	Bird	1	
Anatinae	Duck	Bird	4	
Tetraoninae	Grouse	Bird	4	
		Total Birds	9	
FISH				
	Fish Bones	Fish	7	
	Fish Scales	Fish	54	
		Total Fish	61	0
		OVERALL TOTAL	148	5

The record after the tephra deposition (Components 2, 3, 4) provided evidence for a range of taxa, from fish and birds to very large and very small mammals. When first analyzed, the majority of specimens identified consisted of fish with an NISP of 61 (30.5% of the total identified); however, 54 of those specimens consisted of fish scales and 7 were bones. Since fish scales occur in large quantities and disproportionally distorted the results, only actual bones were included in the analysis. After this modification, the distribution of specimens located after the tephra deposition consisted of large mammals with an NISP of 32 (21.9% of the assemblage), then medium and very large mammals (with 20.5% each), followed by small mammals with 27 (18.5%) identifiable, and birds with 19 (13%). Fish and very small mammals represented the smallest portion of the collection with 7 (4.8%) and 1 (.07%), respectively.

The faunal record prior to the tephra deposition (Components 5, 6) consisted of a very small collection of five identifiable bones. Of this assemblage, three (60%) were assigned to the large mammal size class and one of each medium and small mammals (20% each). The rest of the assemblage was highly fragmented and was not able to be confidently assigned to any size class category by the researcher (3663 specimens, or 94.7% of the entire assemblage). This small collection of identifiable bones was insufficient for any comparative analysis that would yield significant results; therefore, only general observations can be made.

Of the small percentage of the overall faunal assemblage that could be identified beyond size class, there were 11 mammalian species, families, and orders identified, and three bird subfamilies or families. For the below-ashfall components, caribou (*Rangifer tarandus*) were the most abundant with an NISP of 3, then snowshoe hare (*Lepus americanus*) and small rodent (*Rodentia*) each with NISPs of 1. For specimens located above the ashfall, there was a much larger range of species, which is expected considering the much larger sample size. This included snowshoe hare (*Lepus americanus*), cf. beaver (cf. *Castor canadensis*), muskrat (*Ondatra zibethicus*), cf. arctic ground squirrel (cf. *Spermophilus parryii*), rodent (*Rodentia* – small size class), wolf (*Canis lupus*), american marten (*Martes americana*), american mink (*Neovison vison*), moose, (*Alces alces*), caribou (*Rangifer tarandus*), sheep/caribou (*Artiodactyla* – large size class), loon (*Gavia*), the duck subfamily (*Anatinae*), and the grouse subfamily (*Tetraoninae*). This range of species, along with the presence of fish, located at the site could indicate a varied diet breadth for the groups utilizing the site. It is possible that not all species were gathered specifically for food resources; for example, furbearers could have been targeted for their utility in the winter months for their thick, warm pelts and for food when large game were scarce in the region. It is also important to note that not all of the faunal material collected from the site was necessarily acquired or utilized by humans; a portion of these specimens could have been deposited through natural processes. Nevertheless, considering the limited numbers of identifiable bones and amount of species present, it provides an indication of varied site use.

Another consideration of the faunal specimens is the ratio of unidentifiable to identifiable bone. In the pre-ash components there were 1354 unidentifiable versus 5 identifiable specimens. In the post-ash components, there were 2361 unidentified versus 148 identifiable bones. Comparatively, 99.6% of the pre-ash components are unidentifiable, whereas 94.1% of the fauna from the post-ash components are unidentifiable. While the post-ash components included more faunal specimens overall, the ratios or percent of identifiable specimens is actually comparable.

Table 5.8 NISP of identifiable moose and caribou bones by cultural components.

	Cultural Components				
	Post-Ash NISP			Pre-Ash NISP	
Mammal	**C2**	**C3**	**C4**	**C5**	**C6**
Moose	14	3	12		
Caribou	24	2		1	1
Caribou/Sheep		1			1
Total	38	6	12	1	2

For the below-ash fall components, caribou was the most abundant with an NISP of two (and likely three with the sheep/caribou specimen) out of the limited total of five identifiable fragments. Due to the known detrimental effects of tephra on caribou versus moose, additional analysis by component was conducted to achieve a more refined identification. The tight spatial controls for the excavation made it possible to parse apart the occurrences of moose and caribou. I included the caribou/sheep category, as they are likely caribou due to the location of the site and limited sheep habitat in the surrounding area. The outcome aligns with the expectations of caribou as a high-ranked resource for the people utilizing the site, and also the shift towards other game for a period of time if the caribou food source of lichen was negatively impacted (Table 5.8). Only caribou is present before the ash, and then afterwards, only moose in Component 4, occurring immediately after the tephra fall, and then an equal amount of each ungulate (C3), followed by an increase of caribou over moose (C2). This could also indicate that animals which browse on shrubs were less impacted than those who graze on low-lying species of lichens and mosses. This sample size is exceptionally small; however, it could reflect a decline in caribou immediately after the ashfall, given the expectations regarding the effects of tephra on food resource availability for hunter-gatherers in the region.

5.2.4.2 Taphonomy

A wide variety of taphonomic processes affected the faunal collection at the Forty Mile Site (Table 5.9). Burning was by far the most common, both before and after the tephra deposition. The other taphonomic processes that affected the collection included acid wear, cut marks, staining, root etching, and polishing/worked. A small number of the faunal specimens contained evidence of more than one process and were catalogued as such. Polishing and worked bones were categorized collectively as they occurred in such low numbers; both appeared to be human-induced attributes. Analyzing the abundance and occurrence of these taphonomic processes could provide insight into which were intentionally imposed on the faunal collection from people, and those which occurred by other means.

Table 5.9 Taphonomic variables considered and the results.

Taphonomy	Total	Post-Ash	%	Pre-Ash	%
Unaltered	1697	1313	52.3%	384	28.4%
Burned	2017	1103	43.9%	914	67.6%
Cut	5	5	0.2%	0	0.0%
Acid wear	129	84	3.3%	45	3.3%
Stained	2	2	0.1%	0	0.0%
Root etching	2	2	0.1%	0	0.0%
Polished/worked	13	3	0.1%	10	0.7%
Total	3865	2512	100.0%	1353	100.0%

The most abundant taphonomic pattern both above and below the tephra was burning. Thermal alteration affected 914 specimens below the ashfall layer (67.6% of the total below ash assemblage), and 1103 specimens above ash (43.9% of the total above ash collection). The next most frequent for both levels was acid wear, which comprised 3.3% of each collection. Cut marks, staining, root etching and polished/worked bone each comprised less than 1% of either collection. The high number of burned bones at the site is not surprising. Burned material could provide evidence for various types of behaviour; hearth centered food-processing techniques, unintential exposure to heat from overlying hearths, or intentional discard of bones into the fire as a means of site maintenance. There appears to be a slight variation between the components occurring before the tephra fall and those after. The difference in the frequency of burning between the component groups is statistically significant ($\chi2=208.641$, $p<0.0001$). Based on this sample, the groups utilizing the site before the WRAn left behind a greater percentage of burned bones than those occupying the site after the WRAn deposition.

5.2.5 Lithic Analysis

The 2017 excavation produced 1240 lithic artifacts from the Forty Mile Site. Of these, 1043 pieces of chipped stone debitage were recovered. The substantial amount of debitage offered an opportunity to conduct statistical analyses in order to evaluate the differences between the occupations before and after the tephra deposition. There was a great deal of variety in the quality of lithic material recovered in each component. A large majority of the stone tool debitage was located in Component 5 (581 specimens, or 55.7% of the total sample). Within this component, there was a concentrated lithic feature that was partially screened with a finer mesh in order to acquire a sample of very small pressure flakes. This concentration on its own contained 146 flakes that were smaller than 0.05 mm. For the purpose of this lithic analysis, those tiny flakes were excluded in order to be able to compare the assemblage that was acquired utilizing comparable methods.

In order to acquire a larger sample of the entire pre-ash fall period, and given that radiocarbon dating indicated that Component 5 and 6 were deposited around the same time (~2200 cal BP), they were combined (totalling 313 artifacts). The levels occurring post tephra deposition were characterized by small lithic samples; the disturbed levels contained 107 pieces (10.26% of the total), Component 2 had 9 (0.86%), Component 3 had 30 (2.88%), and Component 4 had 3 (0.29%). Component 3 was excavated without any notable disturbances and considered reliable as a foundation for the post-ash representation of lithic use. The material from Component 3 was then compared against the disturbed assemblages (Component 2 and Component 4), for attribute variability by raw material type, flake type, amount of cortex, length, width, thickness, weight, thermal alteration, erailure scars, lipping, platform type, flake termination, platform width and thickness. Overall, while there are minor differences, the components displayed relatively consistent production strategies. Components 2 thru 4 were combined into one post-ash group in order to compare them with the pre-ash components. For the following analysis, all results will be discussed utilizing these grouped assemblages.

5.2.5.1 Raw Materials

There is limited information about the lithic sources in the local vicinity of the Forty Mile Site. However, previous excavators identified a large number of raw materials in their assemblages as well as evidence of river cobble testing and rudimentary or expedient tools (Hammer 2002, Thomas 2003, Thomas 2004). This suggests the utilization of local materials in the form of nodules located along the Yukon and Fortymile Rivers was likely paired with curated materials. They may have been gathered or traded from further away and only reworked or sharpened when necessary. The larger numbers of lithic artifacts, including debitage, that had limited evidence of cortex would support this concept. As the site is located at the confluence of two large waterways, it is likely that many varieties of raw material could be deposited on the shores and exploited as encountered.

A total of 16 raw materials were identified in the 2017 collection, consisting of eight varieties of chert, three chalcedonies, two jaspers, one siltstone, one dacite, and one quartzite (Figure 5.9, Table 5.10, Appendix D for additional data). The raw materials varied in quality, colour, light transmittance, and degree of uniformity. Generally the siltstone, jasper, quartzite and lower-quality cherts yielded heavier flakes in regards to individual weight, whereas the finer and higher quality cherts typically contained smaller/lighter pieces of debitage. Comparing the above and below ash components there is variability in which raw materials were utilized, insofar as some were only identified either above or below the tephra, but there were also several that were utilized bilaterally. Given that many raw material types are present in small numbers, in order to statistically compare raw material exploitation in the pre- and post-ash period, material were grouped based on quality as defined in the methods (Figure 5.10). The frequency of low, medium and high quality raw materials were then compared using a Pearson Chi-square (χ^2) test. While medium quality raw materials dominate both assemblages (accounting for 87.2% in the pre-ash and 91.8% in the post-ash), high quality raw materials were only identified in the pre-ash period (where they account for 6.0% of the sample). Chi-square tests shows significant variation in raw material quality between assemblages (χ^2= 9.393, df=2, p=0.0091). Pre-ash material included 13 types, five of which are exclusive, whereas post-ash there were 10 material types procured, three of which were exclusive. Although there is a variety of quality and use between the components, seven types are shared between them, indicating a high frequency of material was consistently used throughout site occupation. These outcomes could be attributed to differential procurement strategies but it could also be due to availability of the lithic sources available over time.

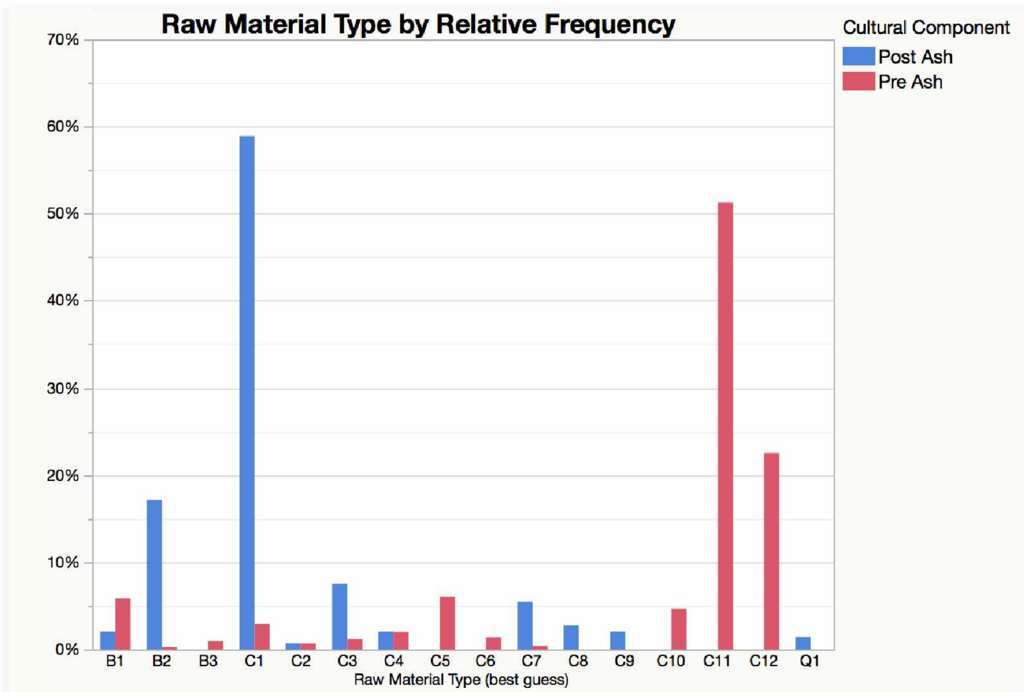


Figure 5.9 Relative frequency of raw material types by component groupings.

Table 5.10 Assigned raw material codes, quality, descriptions, and rock types.

Raw Material Code	Quality	Initial Description	Reassessed Rock Type
C1	Medium	light blueish grey chert	Chert
C2	Medium	light blueish grey chert	Chert
C3	Medium	very dark grey/black, maybe chert	Dacite
C4	Medium	light greenish gray chert	Chert
C5	High	light green/ forest green chert	Chert
C6	Medium	light grey maybe chert	Chalcedony
C7	Medium	light grey mottled maybe chert	Chalcedony
C8	Low	dark red maybe chert	Jasper
C9	Low	light and dark grey chert	Chert
C10	Medium	light blue-grey chert	Chert
C11	Medium	light blue-grey chert	Chert
C12	Medium	light blue-green chert	Chert
B1	Low	very dark grey maybe basalt	Siltstone
B2	Medium	maroon maybe basalt	Jasper
B3	Low	river cobble maybe basalt	Quartzite
Q1	Low	blue and black mottled maybe quartzite	Chalcedony

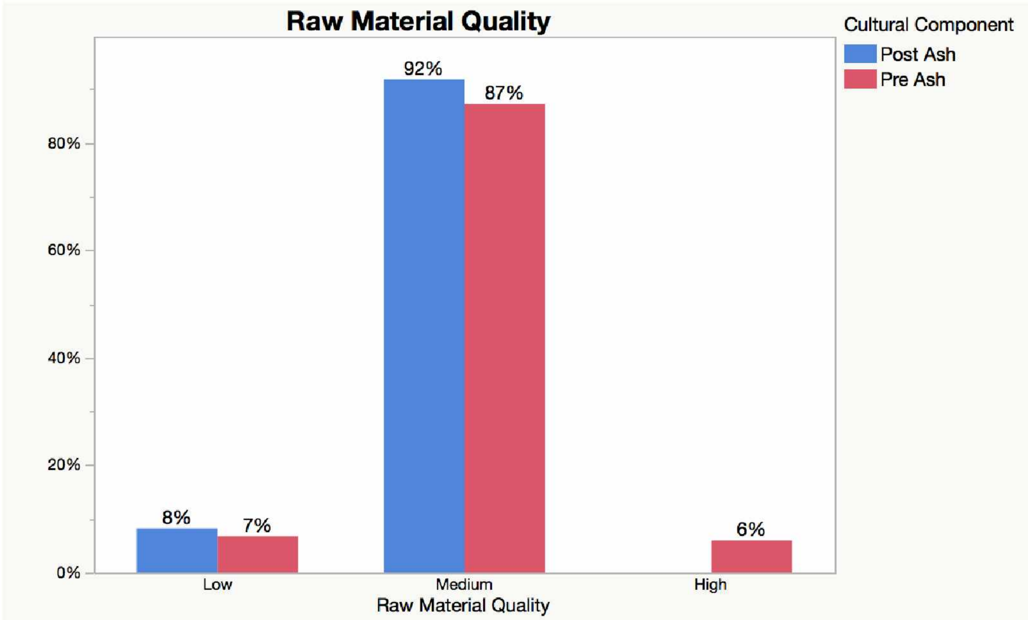


Figure 5.10 Relative frequency of raw material quality by component groupings.

No obsidian was identified during the 2017 excavation; however, it is relevant to note that two obsidian artifacts were identified in the 2003 collection (Table 5.10). Jeffery Rasic of the U.S. National Park Service analyzed the samples in 2012. Both were assigned to the A' (A-prime) geochemical group. While the exact source location of this obsidian outcrop is currently unknown, it has been speculated that it is found in or around the Wrangell Mountains. According to Rasic, "Artifacts from this source are not uncommon in Alaskan sites, but does not show up very often at all in the Yukon. Only one other piece of A' prime obsidian has been found in the Yukon at Fort Selkirk" (Jeff Rasic, U.S. National Park Service, personal communication, 2017). A map displaying the known range of Group A' acquired from Reuther et al. (2011) is located below (Figure 5.11). This dispersal demonstrates interaction with groups located in Interior and Southcentral Alaska to a certain extent. Both the pieces were small flake fragments discovered in the upper two components of the site at the ACM locality, within the same excavation unit. These cultural components both occurred after the fall of the WRAn. The small size of these pieces of debitage shows that the material was not local and highly curated. The occurrence of this obsidian group is on the edge of the known distribution, showing the limits of this network of human interaction. This could provide evidence that after the WRAn eruption, there was increased interaction between groups utilizing the Forty Mile Site and hunter-gatherer groups located to the west and the possibility that immediately after the eruption there was outward mobility from the fallout zone. This mobility could have resulted in increased interaction and relations with adjoining groups.

Table 5.11 Obsidian artifacts analyzed by Jeff Rasic of the US National Park Service in 2012.

Obsidian Database	Artifact #	Description	Locality and Component	Source	Location	Depth (cmbs)
AOD-09766	LcVn-2: 2339	Bipolar Core Fragment	ACM Component 1	Group 'A'	S0E1	5–15
AOD-09767	LcVn-2: 2400	Edge Preparation Flake	ACM Component 2	Group 'A'	S0E1	25–30

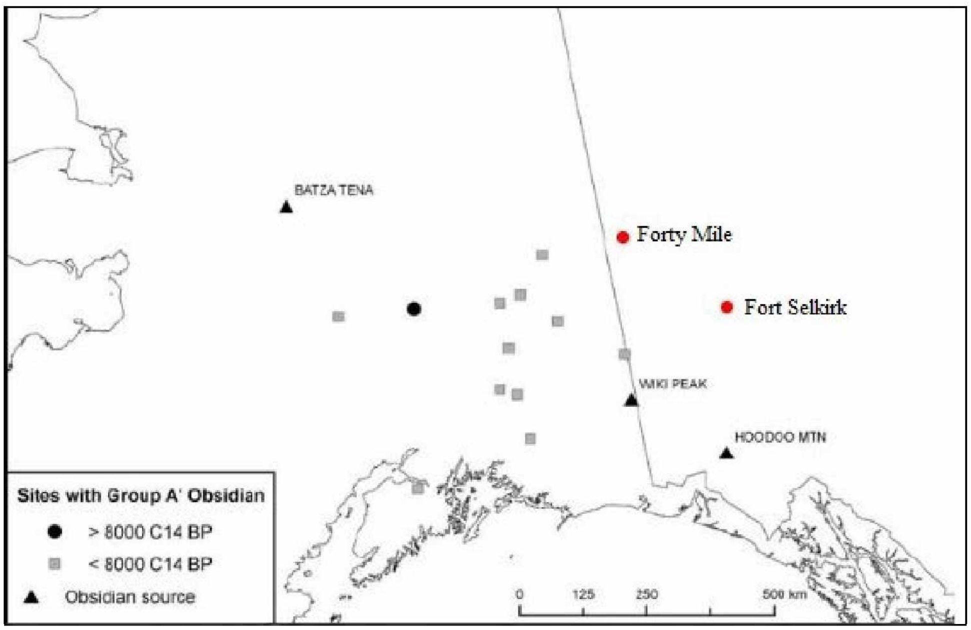


Figure 5.11 Occurrence of A-prime obsidian in Alaska-Yukon (from Reuther at al. 2011:278 adapted to include Yukon archaeological sites).

5.2.5.2 Debitage Attribute Analysis

The extent to which lithic procurement and reduction strategies were mutually employed was evaluated through the attribute analysis. These attributes included flake type, technology type, cortex, maximum length, maximum width, maximum thickness, weight, and thermal alteration. On flakes that had platforms the additional attributes of erailure scars, lipping, bulb of force, platform preparation, termination type, platform width, and thickness were recorded for analysis. All attributes recorded were analyzed utilizing the pre-ash and the post-ash amalgamated components to identify areas of significant deviation or consistency.

Table 5.11 shows the distribution of the various flake types defined by Andrefsky (2001). Statistical comparison was complicated by the nature of the sample, where a number of cells had expected values less than 5 and some had expected values less than 1. From a more qualitative perspective, the component deposited prior to the ashfall contained higher amounts of bifacial thinning flakes by percentage of frequency (8.1% pre-ash verses 0% post-ash), core fragments (0.3% pre- versus 0.0% post-), and simple flakes (87.4% pre- versus 64.4% post-). After the tephra there were higher rates of shatter (25.3% post- versus 1.7% pre-) and decortification flakes (9.6% post- versus 2.3% pre-). Unifacial thinning flakes were limited and occurred in similar amounts across both groupings (0.3% pre- versus 0.7% post-). This suggests that pre-ashfall assemblages contain later stage modification (and maintenance) of formed tools. This is consistent with the recovery of multiple bifacial projectile points associated with these components. After the ashfall, there was an overall reduction in the chipped stone industry (lower density) and more debitage associated with earlier stages of lithic reduction, perhaps cobble testing through flake core preparation and expedient tool forms, such as utilized flakes.

Table 5.12 Flake type by component groupings.

	Post-Ash	Pre-Ash
Bifacial thinning	0	61
Core fragment	0	2
Decortication	14	17
Shatter	37	13
Simple	94	656
Unifacial thinning	1	2
Total	146	751

Table 5.12 presents the data on technology type as defined by Sullivan and Rosen (1985) and as modified by Prentiss (1998). In the post-WRAn component there was higher occurrence for shatter (25.3% post- versus 1.7% pre-), and split flakes (4.1% post- versus 1.3% pre-). The pre-WRAn component had higher percentages of complete (25.3% pre- versus 21.2% post-), broken (22.5% pre- versus 13.7% post-), and fragmented flakes (49.1% pre- versus 35.6% post-). A comparison of the two components using chi-square analysis shows that the differences in the distribution of technological types is significant (χ^2= 137.621, df=4, p<.0001). Once again, this suggests that there were slightly different reduction practices occurring at these times.

Table 5.13 Technology type by component grouping.

	Post-Ash	Pre-Ash
Broken	20	169
Complete	31	190
Fragment	52	369
Shatter	37	13
Split	6	10
Total	146	751

The occurrence of cortex also varies across the two periods (Table 5.13). While specimens with no cortex make up a majority of both samples (96.1% of the pre-WRAn sample and 77.4% of the post-WRAn sample), the difference in the frequency of cortex is significant (χ^2=69.923, p<0.0001); however, the results should be taken with caution due the small sample sizes within the other categories. While the samples from both above and below the tephra had the majority of their flakes devoid of cortex, the post-WRAn had larger percentages of specimens preserving 1-49% cortex (18.5% post- versus 3.6% pre-) and 50-99% of cortex (4.1% post- versus 0.3% pre-). This suggests once again that more early stages of reduction were occurring after the ashfall.

Table 5.14 Occurrence of cortex by component groupings.

	Post-Ash	Pre-Ash
0%	113	722
1–49%	27	27
50–99%	6	2
100%	0	0
Total	146	751

Non-parametric Wilcoxon tests (also known as the Mann-Whitney test) were used to compare metric data from the pre- and post-tephra components (Table 5.14 through Table 5.17). Beginning with length, there is a statistically significant difference between the maximum length of flakes between the two groups (*S*= 77484.5, *Z*= 6.95181, p<0.0001), with a mean length of 9.74 mm pre-ash and 12.53 mm post-ash. There is also a statistically significant difference between the maximum width of flakes between the two groups (*S*= 78943.5, *Z*= 7.47944, p<0.0001), with a mean width of 8.13 mm pre-ash and 10.77 mm post-ash. There is a statistically significant difference between the maximum thickness of flakes between the two groups (*S*= 89787.5, *Z*=

11.72589, $p<0.0001$), with a mean thickness of 1.45 mm pre-ash and 2.85 mm post-ash. Post-ash flakes are significantly longer, wider, and thicker consistent with earlier stage lithic reduction. Pre-ash flakes metrics imply later stage reduction or tool maintenance behaviours. Finally, there is a statistically significant difference between the weight of flakes between the two groups (*S*= 97972.5, *Z*= 11.33525, $p<0.0001$), with a mean weight of 0.35 g pre-ash and 0.64 g post-ash.

Table 5.15 Standard deviations and means for length.

	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Post-Ash	146	12.5299	6.04902	0.50062	11.540	13.519
Pre-Ash	669	9.7394	6.60789	0.25548	9.238	10.241

Table 5.16 Standard deviations and means for width.

	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Post-Ash	146	10.7675	5.45402	0.45138	9.8754	11.660
Pre-Ash	670	8.1331	4.83643	0.18685	7.7662	8.500

Table 5.17 Standard deviations and means for thickness.

	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Post-Ash	146	2.84500	2.15374	0.17824	2.4927	3.1973
Pre-Ash	669	1.45182	1.11766	0.04321	1.3670	1.5367

Table 5.18 Standard deviations and means for weight.

	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Post-Ash	146	0.640753	1.68610	0.13954	0.36495	0.91655
Pre-Ash	751	0.345313	2.78889	0.10177	0.14553	0.54510

All of these tests indicate that the lithics from the pre-ash period are smaller than those from the post-ash period. This is despite the fact that the micro-debitage from Component 5 was excluded from analysis. However, it is also necessary to recognize that the length, width, thickness, and weight variables are not independent of one another. This was confirmed by running a bivariate analysis of these variables (Table 5.18). Using Spearman's rho, these attributed significantly correlated with one another other, with $p<0.0001$. However, this does not take away from the fact that flakes appear to be larger after the tephra fall and smaller before the WRAn.

Table 5.19 Multivariate analysis of metric attributes of the lithic artifact data set.

Variable	By Variable	Spearman ρ	Prob>|ρ|
Maximum width (mm)	Maximum length (mm)	0.4794	<.0001
Maximum thickness (mm)	Maximum length (mm)	0.5530	<.0001
Maximum thickness (mm)	Maximum width (mm)	0.5855	<.0001
Weight (g)	Maximum length (mm)	0.7297	<.0001
Weight (g)	Maximum width (mm)	0.7520	<.0001
Weight (g)	Maximum thickness (mm)	0.8108	<.0001

The occurrence of thermal alteration varies across the two periods (Table 5.19); while specimens with no alteration make up a majority of both samples (97.3% of the post-WRAn sample and 85.1% of the pre-WRAn sample), the difference in the frequency of thermal alteration is significant (χ^2=16.123, p<0.0001). The pre-WRAn had a larger percentage of debitage that is thermally altered (14.9% pre- versus 2.7% post-). This could mean that prior to the tephra fall, lithic material was being heat treated in order to improve the quality. On the other hand, it could be that lithic debitage was thrown into the hearth as a form of site maintenance, as was done with faunal assemblages in the past.

Table 5.20 Thermal alteration by component groupings.

	Post-Ash	Pre-Ash
Absent	142	638
Present	4	112
Total	146	750

There is no significant variation in the occurrence of errailure scars (χ^2=3.327, p=0.0682) or bulbs of force (χ^2=0.017, p=0.8977) between the two component groupings; however, lipping was significant (χ^2=7.692, p=0.0055) (Table 5.20 thru Table 5.22). The occurrence of lipping varies across the two periods; with the pre-WRAn yielding a larger percentage of lipped flakes (39.9% pre- versus 20.4% post-) as would be expected with more maintenance and reduction of tools with acute bifacial edges. This follows the above trend of late stage lithic reduction techniques being more prevalent at the site prior to the WRAn tephra deposition.

Table 5.21 Erailure scares by component groupings.

	Post-Ash	Pre-Ash
Absent	46	336
Present	8	27
Total	54	363

Table 5.22 Bulbs of force by component groupings.

	Post-Ash	Pre-Ash
Diffuse	45	305
Salient	9	58
Total	54	363

Table 5.23 Lipping by component groupings.

	Post-Ash	Pre-Ash
Absent	43	218
Present	11	145
Total	53	363

Performing a Chi-square comparison of the frequency of flake termination attributes was inappropriate as >20% of the cells had counts less than 5. However, it is possible to assess the outcomes qualitatively (Table 5.23). The component prior to the ashfall contained higher amounts of feathered flakes by percentage of frequency (79.8% pre-ash verses 61.1% post-ash). After the tephra there were higher rates of hinge (13.9% post- versus 5.56% pre-), overshot (5.6% post- versus 4.0% pre-), and step flakes (19.4% post- versus 10.6% pre-). The increased levels of feathered termination of flakes could be attributed to increase in skill level of the knapper and/or availability of higher quality raw materials that have more predictable flaking properties or different stages of reduction (e.g., late stage reduction and maintenance of bifacial tools in the pre-assemblages and earlier stage core reduction in the post-ash assemblage).

Table 5.24 Flake termination by component groupings.

	Post-Ash	Pre-Ash
Feathered	22	158
Hinge	5	11
Overshot	2	8
Step	7	21
Total	36	198

Platform width and thickness can also be compared for the pre- and post-tephra components. The pre-tephra sample showed smaller mean values, with a mean width of 4.26 mm pre-ash and 5.72 mm post-ash and a mean thickness of 1.18 mm pre-ash and 1.96 mm post-ash. A comparison of means using the Wilcoxon (Mann-Whitney) test showed that these differences are significant: width (S=13427, Z=2.59043, p=0.0096); thickness (S=15181, Z=4.71328, p<0.0001). Again, these variables do not appear to be entirely independent of one another, as once again the width and thickness of the platforms were significantly correlated (Spearman's rho=0.5873, p<0.0001).

Table 5.25 Standard deviations and means for platform width.

	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Post-Ash	54	5.72481	3.82459	0.52046	4.6809	6.7687
Pre-Ash	363	4.26182	1.89985	0.09972	4.0657	4.4579

Table 5.26 Standard deviations and means for platform thickness.

	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Post-Ash	54	1.95796	1.30940	0.17819	1.6006	2.3154
Pre-Ash	363	1.18287	0.53056	0.02785	1.1281	1.2376

Looking at platform preparation attributes, there was only one occurrence of cortical platform preparation in the whole sample; therefore, it was removed in order to assess the relationship of the majority of the assemblage. The difference in the relative frequency of platform preparation strategies (simple, complex, and abraded) was identified as statistically significant (χ^2=10.709, p=0.0047) (Table 5.26); there was a higher occurrence of simple platforms in the post-WRAn component (44.4% post- versus 24.9% pre-), as well as more abraded flakes (3.7% post-versus 1.7% pre-). The pre-WRAn component had higher percentages of complex platforms (73.5% pre- versus 51.9% post-). Bifacial tool manufacture would produce more complex platforms. This contributes to indications of a more complex lithic tool production, such as bifaces, occurring prior to the tephra deposition, and earlier stage reduction practices occurring post-ash.

Table 5.27 Platform preparation type by component groupings.

	Post-Ash	Pre-Ash
Abraded	2	6
Complex	28	266
Simple	24	90
Total	54	362

Overall, the lithic analysis of the site can provide insight into lithic reduction practices utilized at the site over time. Prior to the tephra deposition, there was a slightly elevated amount of higher quality materials, an increased amount of bifacial thinning flakes, complete flakes, as well as feathered flake termination. In sum, these data provide evidence of later stage thinning and maintenance of bifacial tools occurred. This is confirmed in the lesser amounts of cortex, smaller flakes and platforms by metric sizing, and increased lipping. These attributes indicate an increase in tool maintenance and complex tool manufacture occurring pre-ash, and potentially a higher reliance on a toolstone industry. Increased rates of thermal alteration pre-ash could indicate attempts to improve quality or maintain the campsite for prolonged use. Comparatively, post-ash there are more debitage attributes associated with earlier stages of lithic reduction (shatter, split flakes, higher amounts of cortex, less lipping, less complex platforms), perhaps cobble testing, through flake core preparation and expedient tools forms such as utilized flakes instead of more formal tools. In the following discussion chapter, this lithic data will be combined with the results of the entire site in order to evaluate if these differences are potential responses in human behaviour to the WRAn eruptive event and frame them in context with the known cultural chronology.

Chapter 6: DISCUSSION AND CONCLUSIONS

Prehistoric hunter-gatherers were closely connected to the natural world and were reliant on the local environment to provide the plant and animal resources necessary to thrive. The WRAn was a volcanic event that likely impacted these resources to some degree. Previous research has debated if there was any impact to biota and humans, and if that impact was severe enough to be recognized in the archaeological record. The overall objectives of this project were to analyze the ecological responses to this eruptive event and to gain a better understanding of how people in the past responded to an interior subarctic landscape affected by tephra deposition. Pollen analysis and archaeological excavations were conducted in the WRAn tephra-affected area to address these objectives. The pollen data provide context on the local vegetation communities before and after the WRAn eruption and offers insight into the ecological responses to tephra accumulation over this landscape. The archaeological data provide context for the cultural setting before and after the ash fall and provide opportunities to analyse the human responses to changes in local subsistence resource fluctuations within the WRAn tephra affected area. This research contributes data that argues there was an impact to the environment and people. However, it was not as severe as some researchers have noted and should not be defined as a long-term catastrophic event.

This chapter is separated into three sections: section 6.1 presents a discussion of the pollen results; section 6.2 discusses the results of the archaeological excavation and considers the site data within the current understanding of interior Alaskan/Yukon hunter-gatherer chronologies and behavioral adaptation to boreal environments; and section 6.3 offers some general conclusions of this study.

6.1 VEGETATION RESPONSES TO TEPHRA

The discussion of vegetation response to WRAn tephra deposition will draw on the research questions and expectations outlined in Chapter 1, and the results of the pollen analysis in Chapter 5, to identify possible effects to the local environment following tephra accumulation.

Decadal-scale pollen sampling from a lake core in a northern tephra-disturbed landscape sheds light on short-term vegetation responses to the tephra fall. However, not all taxa responded equally after tephra deposition and the regeneration sequence occurred over ~30 years before a return to relative pre-eruption levels. While it is not possible to equate pollen abundance to vegetation abundance exactly, it is possible to draw general conclusions with comparisons to other studies of vegetation succession in volcanically influenced landscapes. After 35 years of research at Mount St. Helens, it has become apparent that multiple trajectories of vegetation succession are expressed on the landscape that are based on a wide array of disturbance variables and the intricate interaction between numerous species: "Succession at Mount St. Helens is not dominated by time since disturbance but rather by convoluted and often contradictory biotic and environmental interactions through time" (Allen et al. 2018:213). The results of the pollen analysis at 6-Mile Lake conform to Allen et al.'s observations on succession and provide insight into local ecosystems that were likely adversely affected by the tephra, but persisted and returned to a somewhat similar state.

The spikes in pollen abundance at ~15 yrs and ~30 yrs post-ash could be the result of varying levels of environmental stress, elimination of competition, quantity of colonizing species, time required for local plants to re-establish, or a combination of these and other factors. The amount of pollen that is produced and dispersed is reliant on a number of factors. A plant that is freely exposed produces many times more pollen than one that grows in a dense forest (Faegri and Iversen 1989); therefore, it is not always the case that more pollen equals more vegetation on the landscape. While not universally tested, it has been documented that some species produce more pollen under stress in order to ensure future survival (Wong 2018). On the other hand, moisture and temperature drive shifts in plant distribution over time (Anderson et al. 2004). And since volcanic activity can create a wide range of temporary environmental changes, both in the Earth's atmosphere and at its surface in soils (Crisafulli et al. 2005; Blackford et al. 2014), it could prompt temporary vegetation transformations. After comparing succession rates following two different eruptions (Mount St. Helens and Surtsey), Del Moral and Magnússon (2014:2109) conclude that "isolation and stress leads to initially variable vegetation. The result is frequently local dominance by different species with similar ecological characteristics. At both locations, the alleviation of stress by physical and biological processes accelerates succession rates, although the mechanisms may differ." This progression could also explain the two discrete peaks that occur during the height of pollen productivity at 6-Mile Lake.

The vegetation timeline from the analysis of 6-Mile Lake pollen suggests:

- 0-5 years produced a marked reduction in pollen abundance
- 15-30 years following the tephra fall was highly productive for some taxa

- ~35+ years after the ash fall is a return to relative pre-ash conditions

This framework for vegetation responses could reflect a plausible successional pattern for this region after a land disturbance, and a preliminary decrease in pollen productivity is expected after an environmental disturbance. All biota would have experienced some amount of trauma, stress, or modification to their typical existence, either from tephra deposition, toxic chemicals in the air, or modification of the soil environment (Antos and Zobel 2005). Most plants likely decreased in abundance on the landscape or were damaged in a way that could inhibit pollen production, even if temporarily. It is reasonable to expect that certain species recovered more quickly than others, and surviving species would regenerate to varying levels of success in patches on the landscape creating competition, increased pollination, and possible changes to soil moisture and temperature over a ~35-year period before stabilizing and returning to similar pre-eruption homeostasis.

6.1.1 Specific Pollen Taxa

The influx diagram presented the specific taxa that were producing pollen in higher abundance post-WRAn deposition. The initial increase in pollen influx ~15 years after the eruption was driven by *Poaceae* (grasses), *Betula* (birch), and *Alnus* (alder) production. There is a slight decrease of all taxa, and then a second increase in pollen influx ~30 years after the ash-fall that is driven by the *Cyperaceae* (sedges), *Picea* (spruce), and, again, *Betula* (birch) production. These rises in pollen influxes could be attributed to a particular species' characteristics relative to resilience and response to disturbances and/or the amount of damage inflicted on the plant in the aftermath of the environmental disruption (Zobel and Antos 2018). The pollen record was dominated by wind-pollinated taxa because the collection site is a lake. Lake records tend to underestimate insect-pollenated taxa because of the low probability that a pollen-laden insect would be present at the coring site.

It is possible to delve further into the common traits of these plant taxa and determine to what degree the tephra could have disrupted the local environment by identifying the main pollen influencers. A switch from increased grasses to sedges within the understory could suggest modification to the soil moisture capacity or chemical composition over time (Blackford et al. 2014). Generally, grasses prefer drier conditions, whereas sedges are more mesic (Hulton 1968). Studies at Mount St. Helens demonstrated that the thicker, the tephra the greater negative impact on herbs, whereas the extent of snow cover had a greater negative effect on woody taxa (Zobel and Antos 2018). Therefore, it is likely that the WRAn tephra thickness of at least ~1 cm was not detrimental to grass and other herbaceous taxa growth, as they were able to produce pollen at increasing rates within 5 years after the eruption.

Birch, alder, and *Populus* were the first to show increases in productivity among the woody taxa. *Populus* has the ability to reproduce vegetatively (Zasada and Phipps 1990), and as long as it survived the tephra fall, it would be able to expand on the landscape immediately afterwards and continue pollenating in succeeding years. Alder fixes nitrogen from the air (Furlow 1993), which would assist in its expansion as well as the regeneration of soil composition post-eruption. Birch and alder are both abundant in the local environment and able to be present as both shrub and tree varieties, which are difficult to distinguish between pollen grains. Tree birch and shrub birch are able to freely hybridize and prosper in disturbed landscapes (Flora of North America Association). Mount St. Helens successional studies found that alder was one of the main contributors to community divergence and one of the most abundant trees between year 14 and 30 in one of the heavily disturbed regions (Dale and Denton 2018). In the WRAn pollen analysis, it is also notable that all three of the tree and shrub taxa that appeared in abundance post-ash were deciduous trees that have shrub varieties in the local environment, making them extremely flexible and resilient.

It was not until the second spike at ~30 years post-ash that spruce pollen rates hit their peak, along with willow. It could be that the conifer needles were damaged and took longer to repair, or simply took longer to recover from the effects of the tephra than the alder, birch and *Populus*. The eventual increase of conifers could be attributed to the fact that the ashfall eliminated competition with other plants, specifically groundcover, and created an opportunity for expansion to areas that were not previously available. Spruce saplings require at least a decade to mature and produce seeds/cones (and presumably pollen). According to USDA research (Nienstaedt and Zasada 1990), the maturation of spruce occurs between 10-15 years but does not reach peak seed production until 30 years or older. This could indicate an initial spruce recruitment following the tephra fall, which is only visible in the pollen record once these trees reach maturity ~30 years later. It is surprising that willow was not one of the initially productive species since they are early successional species. However, they do come back in higher rates during the second spike in the pollen record.

During the analysis two cf. *Juniperus* (cf. juniper) pollen grains were identified after the WRAn. It is necessary to note that juniper is characteristically difficult to identify due to its non-descript characteristics and similarities to spores. This is the reason for the cf. designation, even with additional review of the data. Juniper typically thrives on dry hillsides and could indicate that drier conditions were present near the study site. These juniper grains were identified in the first spike post-ash in the same sample where grasses (*Poaceae)* were also at their highest levels; both are species that prefer drier conditions.

6.1.2 Seasonality

The results of this pollen analysis do not provide definitive evidence regarding the time of year in which Mount Churchill erupted and produced the WRAn tephra. The pollen data are inconclusive as to whether the WRAn eruption occurred in the winter, as determined by MacIntosh (1997), or in the summer, as established by Hanson (1965) and West and Donaldson (2002). The season of the tephra fall may affect vegetation succession sequences, as plant recovery is based on a range of factors including the size of plant, depth of snowpack, erosion, and tephra thickness. The recovery of vegetation communities can be complex and variable based on the composition of pre-eruption vegetation types or species (Antos and Zobel 2005). The time period of ~5 yrs of lowered influx rates and decline in pollen productivity is rapid in terms of vegetative responses. In combination with only ~1 cm of tephra deposition, it is clear that the recovery rate of the local plant life was relatively rapid, and whether this was due to the presence or absence of snowpack or other seasonal factors cannot be determined at present. Identifying the season of tephra deposition would narrow down the potential factors that could point to why the vegetation community pre-WRAn responded to ash-fall as indicated in the pollen analysis; however, at present a definitively seasonal interpretation of the timing of the WRAn eruption remains inconclusive.

6.1.3 Effects of Environmental Change for Wildlife

Animals in tephra fallout areas would likely experience disturbances to their environment and food resources. Shrubs would be free from thin layers of tephra, allowing browsers such as moose to be relatively unaffected (Riehle et al. 2000). The spike in shrub pollen could indicate that browse for moose increased in the fallout region, possibly promoting a more abundant moose population for a brief time after the WRAn eruption. Mammals, such as caribou or sheep, who primarily graze on low-lying plants, including lichen, grass, sedges, and moss, would be negatively impacted as their food resources would be covered in ash. The abrasiveness of glass particles in tephra could cause detrimental tooth wear and possibly trigger temporary migrations of these animals into regions with more readily accessible food resources (VanderHoek and Nelson 2010). Lichen could not be directly captured in the pollen analysis, but it is relevant to note that lichen was likely one of the most significantly affected species due to its diminutive size and short stature, when compared to other plant species. However, lichen are able to survive thin layers of tephra less than 10 cm and after long periods of time can eventually recuperate (Grishin et al. 1996).

In contrast to larger mammals, small mammals living in burrows are offered some amount of protection from tephra and, depending on their diet, would be less impacted following the eruption. In areas of refugia, small mammals could provide needed resources to carnivores and hunter-gatherers (Crisafulli et al. 2005). For fish species, spawning seasons and the flow rate of the water can influence their abundance within particular watersheds after tephra deposition (Riehle et al. 2000). Generally, the slower and smaller the stream the greater the impact to the fish, as it takes longer for the tephra to be vacated from the system. The Yukon and Forty Mile Rivers are both considerable high-volume waterbodies and it is likely that the fish resources were not heavily impacted.

6.2 Human Responses to Tephra

The second portion of this research considers the human behavioural responses at the Forty Mile Site to the WRAn within the context of the post-ash vegetation response developed through the pollen analyses. These responses are also addressed in the context of broader cultural transformations recorded in the region between the Northern Archaic tradition (Taye Lake Phase) and the Late Prehistoric period. The Forty Mile Site faunal collection post-tephra displays a wider variety of resources targeted that coincide with our expectations that temporary changes to food resources would have been necessary. While diet breath at the site could have changed following the WRAn eruption, currently the faunal small sample size is too small to be able to reliably reconstruct and discern significant change. Artifact analysis and site evaluation indicates a transition prior to the WRAn eruption that was already in motion towards a more highly mobile logistical site selection and movement, typical of the time period, and away from residential mobility strategies. Given what is known about human responses to tephra, the results of the archaeological analysis draw on insights and previous research to identify possible impacts to the local environment that might have affected people following the WRAn eruption.

6.2.1 Faunal Material and Subsistence

Post-ash components provided more identifiable faunal taxa than pre-ash components, presumably due to the sampling bias relating to the number units excavated below the WRAn deposit. Regardless of this bias, the post-tephra record provides evidence for a wide range of taxa, from fish and birds to very large and very small mammals, and a range in diet breadth that indicates the possibility of logistical mobility strategies in place and exploiting the site for specific resource opportunities throughout the seasons for over 2000 years. The previously excavated North locality at the confluence of the rivers supports the seasonal use of the site by the presence of fish (likely salmon) specimens; fish remains were not found in the upper components at the ACM locality. The presence of fish located solely at the North locality suggests a landform preference at the confluence for specific periods of time during the year when fish were in abundance, and people could capitalize on this opportunity before moving on to other resource patches. This would reflect an interpretation of higher logistical mobility because while a variety of animals were targeted there is a clear bias toward fish.

As browsers, moose would likely be minimally impacted by tephra deposition, as thin layers of tephra would have little effect on shrubs. In contrast, mammals who graze, such as caribou and sheep, would be highly affected by their food resources covered in ash causing significant tooth wear and the possible necessity to migrate from the region. The faunal results confirm that moose were on the landscape throughout or very soon after the tephra deposition in the study region. This presence of moose in the Forty Mile Site also coincides with the shrub spikes in the pollen data.

Caribou remains, on the other hand, are not present immediately following the WRAn in Component 4, indicating that they potentially vacated the region, or were not available to the same degree post-ash. However, they do reappear in the faunal record and overtake moose as the leading large game resource in Component 2. The presence of caribou in both pre- and post- tephra components is expected, as the site was known ethnographically as a hunting intercept point. Caribou comprised 3 of the 5 identifiable bones in the limited pre-ash assemblage, which could exhibit the importance of the resource prior to the eruption and the eventual dominance of caribou within the regional subsistence economy over time. However, these interpretations are purely speculative, as it is difficult to produce sound conclusions with the small size of the pre-ash sample.

The Forty Mile Site does include a large portion of fragmented and unidentifiable bone. The increased NISP located above the ash could partially be due to differential processing and discard practices of pre-contact hunter-gatherers, but could also be due differential preservation. Highly fragmented bone can be argued as representing times of nutritional stress due to the fact that it takes a significant amount of additional effort to breakdown bones to access marrow and then boil in water to acquire the grease (Binford 1978). It is well documented that hunter-gatherer groups commonly fragmented bones in order acquire additional nutrients (Binford 1978; Outram 2001). Comminuting bones in order to render the grease is a separate act than burning them; however, after acquiring an abundance of highly fragmented bones it would be practical to subsequently deposit them into the hearth for food deposition and site clean-up (Clark and Ligouis 2010). On the other hand burning bone also promotes greater fragmentation. While it is difficult to determine if the bones were fragmented before or after burning, the presence of fire cracked rock and large cobbles at the site suggests that some amount of additional processing of fauna was conducted before and after the WRAn.

It could be argued that *if* the WRAn caused significant changes to the local ecology, there would have been a certain amount of stress to animal resources for the local inhabitants. This could result in people additionally processing faunal resources in order to acquire as many nutrients and calories as possible. However, the faunal remains from the Forty Mile Site show the opposite trend. There are fewer fragmented bones and more intact, identifiable bones after the ashfall than beforehand. This could be an indication that there were other options on the landscape for nutrition and further processing was not necessary. The first presence of moose at the site is directly following the WRAn eruption coinciding with a temporary absence of caribou. Mobility patterns in the region since the Northern Archaic show reliance on resources like caribou and fish that seasonally congregate in higher abundances. If the Forty Mile Site were utilized as a hunting campsite primarily for caribou, a temporary disturbance due to the tephra deposition would have presented the option to target moose as an interim resource. This suggests human flexibility and resilience when faced with resource fluctuations, but when caribou became available on the landscape they once again became the preferred choice.

6.2.1.1 TAT'TLA MUN SITE FAUNAL COMPARISON

The Tat'tla Mun Site (KdVa-8) was occupied from 3945 cal BP to the historic era and was covered by WRAe tephra deposition (Figure 6.1). This site is contemporaneous with the occupations at the Forty Mile Site and presents an opportunity to compare faunal collections (Table 6.1) across the region that were affected by ash falls.

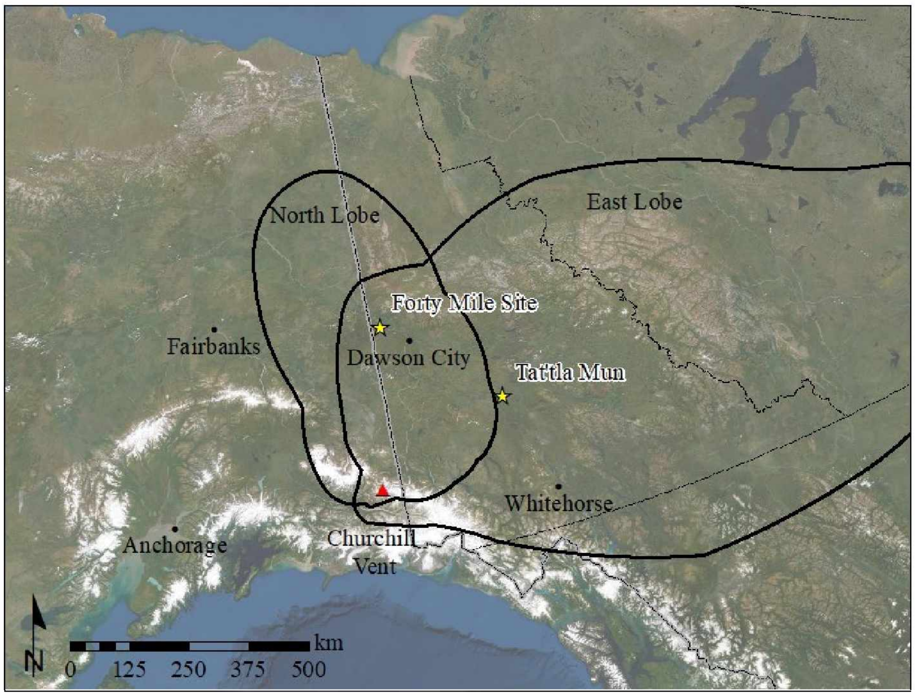


Figure 6.1 Map of Forty Mile Site and Tat'tla Mun, including location of Churchill Vent, North Lobe and East Lobe (distributional data from Mulliken et al. 2018).

Thomas (2003) suggested that the pre-ash component of Tat'la Mun has higher frequencies of animals with greater food value and that the shift toward lower food values after the tephra could be a result of increased stored food without bone, which would not be present in the faunal record. There are higher numbers of furbearers, which could indicate varying game selection patterns toward animals with lesser food values. The Forty Mile data, in contrast, shows a higher abundance of large ungulates and a variety of small mammals. This could be due to the location of the site and use as a caribou intercept point. This dissimilarity between the Forty Mile and Tat'tla Mun faunal assemblages could also represent differential site selection based on available resources, or seasonal resource preferences between the Northern Tutchone at Tat'tla Mun and the Hän/Upper Tanana at Forty Mile. Overall, both sites show a wider diet breath (although difficult to confirm due to small sample size) following their respective eruptions regardless of the specific differences between the faunal assemblages. The transition from Taye Lake to the Late Prehistoric period at Tat'tla Mun represents an *in situ* development based on the broad similarities in the settlement and subsistence patterns (Thomas 2003). The same conclusion is drawn from the Forty Mile Site.

Table 6.1 Forty Mile and Tat'tla Mun faunal comparison of NISP values.

		Forty Mile		Tat'tla Mun	
Taxon or Family	**Common name**	**Post-Ash NISP**	**Pre-Ash NISP**	**Post-Ash NISP**	**Pre-Ash NISP**
MAMMALS					
Lepus americanus	Snowshoe Hare	6	1	8	
cf. *Castor canadensis*	cf. Beaver	3		28	23
Ondatra zibethicus	Muskrat	1		33	6
cf. *Spermophilus parryii*	cf. Arctic Ground Squirrel	1			
Rodentia	Rodents	5	1		
Canis lupus	Wolf	1			
Ursus	Bear			9	1
Martes americana	American Marten	4		1	
Neovison vison	American Mink	1			
Alces alces	Moose	29		2	3
Rangifer tarandus	Caribou	25	2		1
Artiodactyla	Sheep/Caribou	2	1		
	Total Mammals	78	5	81	34
BIRDS					
Gavia	Loon	1			
Anatinae	Duck	4			
Tetraoninae	Grouse	4		2	
	Total Birds	9	0	2	0
FISH					
	Fish Bones	7		12	18
	Fish Scales	54			
	Total Fish	61	0	12	18
	OVERALL TOTAL	148	5	95	52

6.2.2 Lithic Material

Lithics excavated during previous work at the site include a small assortment of end scrapers, projectile points, cobble spall scrapers, retouched/utilized flakes, an adze, and cores. While the excavation conducted during this research contributed three utilized flakes and a cobble scraper, it is imperative to note that the only two projectile points that have been uncovered at the Forty Mile Site were side-notched and recovered from the pre-ash components. Side-notched bifaces are a hallmark of the Northern Archaic/Taye Lake phase, and while this iconic tool type was persistent in the region up until ~1250 cal BP, it is only presented in the pre-ash components that date between 2150-2480 cal BP. This could indicate an earlier transition at the site or could serve as evidence that post-ash reoccupation of the area did not require specific aspects of the Northern Archaic/Taye Lake phase toolkit that were previously dominant pre-WRAe deposition.

The analysis of the debitage provided an avenue to gather more information on the site and delineate variability. A previous analysis of the North locality debitage from 1998-2000 conducted by Hammer (2002) indicates a free-hand reduction technique that is dominated by late and early stages of reduction. The analysis of the 2017 excavation's lithic debitage collection detected statistically significant differences between the pre-ash and post-ash components. To reiterate, prior to the tephra deposition there was a preference for higher quality materials, increased rates of bifacial thinning flakes, and complete flakes with feathered flake terminations, all providing evidence that later stage production and maintenance occurred. This was consistent with lesser amounts of cortical materials, smaller flakes and platforms, increased presence of platform lipping, and increased rates of thermal alteration. These differences were identified statistically with the caveat that the sample sizes between these component groupings were distinctly different with 751 pieces from the pre-ash assemblage and 146 from the post-ash assemblage. This decrease in chip stone debitage also aligns with the culture history of the region moving into the Late Prehistoric Period, which shows a trend towards more osseous materials and a decrease in lithic industries.

Raw material was dissimilar between the two component groupings and could be attributed to differential procurement strategies or the availability of lithic sources over time. There are no known primary lithic sources in the immediate vicinity of the Forty Mile Site. Higher quality material may have been traded or curated to a higher degree. It was determined that in the pre-ash components, there were smaller and lighter flakes overall, which would also support this interpretation. The hunter-gatherers using this site during the pre-ash components could have traveled more frequently to areas with different raw materials or traded more heavily with neighbours in order to acquire higher quality toolstone. This could imply differing procurement strategies of resources, a higher utilization of chip stone tools, and increased movement on the landscape.

In terms of the two pieces of A' obsidian located at the site, according to Rasic, "Artifacts from this source are not uncommon in Alaskan sites, but does not show up very often at all in the Yukon. Only one other piece of A' obsidian has been found in the Yukon at Fort Selkirk" (Jeff Rasic, U.S. National Park Service, personal communication, 2017). Both of the Forty Mile Site pieces were small flake fragments discovered in the upper two components and within the same excavation unit at the ACM locality. These cultural components occurred after the WRAn tephra fall. The small size of these pieces of debitage may indicate that the material was highly curated.

Figure 5.1 (Chapter 5) refers to the known distribution of Group A' found in archaeological sites in Alaska and Yukon. The geographic spread of Group A' found in these sites demonstrates interaction with groups located in interior and southcentral Alaska and Yukon. The Forty Mile Site is at the edge of the known distribution for this obsidian group, showing the limits of this network of human interaction. This could provide evidence that after the WRAn eruption there was increased interaction between groups utilizing the Forty Mile Site and hunter-gatherer groups located the west. It also points to the possibility that immediately after the eruption there was outward mobility from the fallout zone. This temporary relocation could have resulted in increased interaction and relations with adjoining groups, strengthening social ties over the long-term. This is also consistent with connections ethnographically and linguistically between the Hän and westerly-located Upper Tanana groups (Haynes and Simeone 2007).

6.2.3 Land Use and Site Function

An observation from the radiocarbon results was that pre-ash Components 5 and 6 occupations occurred very close in time. When both of these occupations were observed in the same excavation units in 2017, they were only separated by a few centimeters of sediment and the radiocarbon ages indicate that they are statistically indistinguishable and occurred in very close succession. The artifacts associated with Components 5 and 6 consisted of multiple hearth features including lithics and/or broken bone (both burned and unburned), birch bark coils, and fire-reddened soils. This type of activity could indicate that the site was used repeatedly over a period of time for similar activities.

Another inference from the radiocarbon dates is the overlap between the ACM Component 2 and one of the cultural occupations of the Northern locality at the river confluence. They both occur at similar depths below surface and could indicate the time at which the surface of the landform at the confluence became more stable. While it is possible that the confluence was utilized prior to this radiocarbon date, the excavation units conducted in 2001 produced culturally sterile silts below ~80 cmbs (Hammer 2002). This could assist in interpreting the total useable space on the landform. It has previously been stated that in many respects the occupations of the Late Prehistoric Period/Athabascan Tradition of the ACM locality can be seen as an extension of the North locality (Hammer and Thomas 2006). While this is entirely possible, it could also be true that these locations were favourable during different seasons or for differing resource acquisition purposes. The Hän and Upper Tanana ethnographic accounts suggest that salmon (and other fish) and birds were the predominant resource in the summer months, whereas caribou and small mammals were the targeted resources over the winter (Allen 1887; Schwatka 1900; Schmitter 1910; McKennan 1959; Osgood 1971; Crow and Obley 1981; McKennan 1981; Halpin 1987; Mishler and Simeone 2004; Haynes and Simeone 2007). The North locality is close to the river confluence for salmon fishing in the summer, whereas the ACM locality is located on the raised bench along the Yukon River for hunting large and small mammals in the winter. The two localities are approximately 350 m apart and located on differing elevations along the shoreline. Due to their close proximity, it seems unlikely that both loci were utilized contemporaneously for a base camp. However, it could be that certain areas were more desirable during different seasons, or for various resource gathering needs. People utilizing the area would have maintained a campsite and exploited resources over some distance surrounding the living area. As both localities produced highly stratified excavation units with continuous occupations and hearth features, it is plausible to suggest that the landform was utilized as a part of a hunter-gatherer logistical organization system with groups continually returning for longer periods of time and setting up camp somewhere along the landform as resources were required or replenished.

6.2.4 Cultural Chronology Context

The Forty Mile area has been ethnographically recorded as a Spring grayling fishing locale, a caribou intercept point for the Fortymile herd, and likely a salmon fishing site as well (Mishler and Simone 2004). There is a wide range of locally available resources and multiple seasons in which people could have utilized the site. However, the site contains limited evidence of a long-term, continuous occupation. The site generally consists of unlined hearth features scattered throughout the landform on both the North and ACM Localities. The diet breadth reconstructed in the faunal record, combined with the reoccupation of the site for short periods of time, is consistent with the ethnographic understanding of the time period, which included fish, birds, and mammals exploited on the landscape during seasonal abundance.

Archaeologically, the site is situated broadly at the transition between the Taye Lake Phase and the Late Prehistoric Period in the Yukon chronology, and Northern Archaic and the Athabascan Traditions in the Alaskan chronology. These chronological phases contain many similarities and each describe a transition toward an increase in bone and antler tools, general reduction in flaked stone industry, increase in native copper use, higher frequency of fire-cracked rock, a birch bark industry, and the presence of Kavik-style points (Dixon 1985; Le Blanc 1984; Workman 1978; Shinkwin 1979). In the southwestern Yukon, this is most iconically displayed at the alpine ice patch sites with the shift from atlatls to bow and arrow technology ~1200 cal yr BP (Hare et al. 2012). The excavations at Forty Mile and the differences detected between the pre-ash and post-ash components align with the general trends of toolkit, site use, and resource procurement occurring in the region with a certain degree of overlap. This relationship to other transitions in interior Alaska and northern Yukon suggests that this was a wide-scale modification and not a localized occurrence that was sparked by a single event.

There is evidence of worked bone in the pre-ash components, with an increase in occurrence post-ash. The Forty Mile Site has four worked bone tools as part of the assemblage. One was a bone tip, likely an awl, uncovered in the pre-ash level. Two worked bone tips and one worked rib bone were identified in the post-ash level. This small assemblage indicates the use of bone as a tool resource throughout the occupation of the site. A developed bone industry aligns with both the Taye Lake Phase and the Late Prehistoric period toolkits. The permanence of bone tools throughout the occupation of the site displays the continuity of particular tools over time. In addition, the increase in unburned bones could signify differing processing techniques that favoured utilization of bone in various ways other than burning. There is marked reduction of lithic debitage at the site, which is amplified by the limited pre-ash units excavated. As identified by the analysis, the pre-ash assemblage displays evidence for late stage tool production. This could be an indication that people were transitioning away from chip-stone tool manufacture as their primary toolkit and towards more osseous materials in the Late Prehistoric/ Athabascan period (Hare et al. 2001).

Other evidence at the site for a cultural transition occurring prior to the WRAn eruption is present. Fire-cracked rock was recorded in hearths throughout the stratigraphy showing consistent utilization; however, these increase in frequency over time. Evidence of birch bark is recorded in components both pre- and post-ash. However, there is currently no evidence of native copper at the site, nor for Kavik-style points from above or below the tephra. The absence of projectile points post-ash is marked, especially with the recovery of two side-notched points identified in the components older than 2000 yrs BP. The presence of A' obsidian in Components 1 and 2 provide evidence for later connections with Alaskan groups. The introduction of fish and bird bones post-ash could indicate logistical resource procurement at the site over time, and a more broad-based system being established.

And finally, a significant indicator that any differences between the pre- and post-ash assemblages were part of a cultural transition already transpiring is the occurrence of the bone feature and hearth in Component 4; which occurred with very limited sediment immediately above the WRAn (<1 cm in some locations). This feature contained identifiable moose fragments and is direct evidence that if the site did experience a hiatus due to the tephra it was only for a very brief period of time. The two median radiocarbon dates of Component 4 of 1477 and 1632 cal yr BP demonstrate that reoccupation after the WRAn eruption of 1625 cal yr BP (Reuther et al. 2019) could have been within 7 years. It would be difficult to argue that massive cultural transition occurred in the region in less than a decade, and it is more likely that the same groups persisted in the region and were able to return to their known hunting grounds once recovery was adequate. This resilience of the hunter-gatherer populations in the region to adapt and persist in response to a natural disaster is remarkable.

Overall, while the analysis of the Forty Mile Site reflects a difference in artifact and land use over time, these changes appear to have been already in motion prior to the WRAn and align with other sites in the region. For example, Ta'tla mun Lake in central Yukon experienced the effects of the WRAe and analysis suggests an *in situ* development between the Taye Lake and Late Prehistoric phases along with tangible external influences (Thomas 2003). Recently, published investigations in the Tanana region of Alaska have also reported observations that archaeological assemblages in the region dating before the WRAn tephra yielded larger, richer lithic assemblages, as well as evidence for immediate reoccupation (Lynch et al. 2018). Investigations into the Fortymile river drainage by the Bureau of Land Management and the Museum of the North have produced a wide range of prehistoric land-use patterns in the area dating to both before and after the WRAn including a cache pit, house pit, hearths, and a possible lookout site (Coffman et al. 2018). These sites produced a range of landscape and resource use over time and were likely occupied by the same people utilizing the Forty Mile Site as part of a broader subsistence pattern.

6.3 Conclusions on the Effects of WRAn

This project contributed high-resolution results to both the pollen and archaeological record, and provides insight toward the potential effects that the Northern Lobe of the White River Ash eruption at the Yukon-Alaska border may have had on the local environment and hunter-gatherer groups living in the Forty Mile Site region. Results suggest that the eruption did not create a prolonged negative environmental or cultural impact.

A few potential differences in cultural occupations must be considered in relation to established transitions in settlement and subsistence systems of hunter-gatherers in the Yukon and Alaska. HBE models state that methods of resource procurement and mobility patterns are affected by the availability and predictability of resources on the landscape (Kelly 1983; Winterhalder 2001). Therefore, the modifications of hunter-gatherer resource use before and after the WRAn in the archaeological record must be analyzed within the appropriate cultural context to identify if these changes were solely due to responses to ecological change, or if they are part of the wider system of cultural transition already occurring. At Forty Mile, there is a prompt reoccupation of the Forty Mile Site, with multiple subsequent occupations, displaying a resilient population that was able to adapt to resource fluctuation across this landscape. Although natural disasters such as these could have spurred on more dramatic responses of hunter-gatherers to changes in local environments and accelerated cultural transformations, at the Forty Mile Site they were not likely the sole catalyst. No hiatus in cultural occupation of the Forty Mile Site occurs following the tephra deposition and the archaeological assemblage follows the broad changes in technology, settlement, and subsistence patterns through time throughout southwestern Yukon and interior Alaska.

The pollen record indicates a period of ~35 yrs of ecological flexibility in the region after the WRAn tephra deposition. The vegetation experienced a temporary decline immediately after the volcanic event followed by ~15-30 years of increased pollen influx before stabilizing to near pre-eruptive levels. This range of three decades would make it possible for the local human population to temporarily utilize periphery locations or expand their diet breadth while waiting for environmental recovery within the Forty Mile Site region. Due to the established patterns of mobility and subsistence practices in place at the time, it is likely any negative consequences experienced in the fallout of the WRAn were quickly mitigated and strengthened by connections with neighbouring groups.

This study was able to address many of the preliminary questions regarding the effects of the WRAn for the people and the environment. However, with this knowledge, further questions are generated and ambiguities revealed. Future investigations into the environmental impacts of the WRAn may consider the effects in regions with different tephra thicknesses. The study area for this project has a recorded isopach thickness of between 2−8 cm (Lerbeckmo and Campbell 1969; Lerbekmo et al. 1975), and locations with thicker deposits likely had more extreme effects. This study was able to identify similarities with historic eruptions like Mount St. Helen's and use it as an analogy for the effects on certain flora and fauna. However, it is unknown if this analogy would be effective for the entire eruptive footprint. Another fruitful avenue of research is the specific investigation into the seasonality of the tephra deposit. Discussion into the two debates for seasonal deposition was addressed (Hanson 1965; MacIntosh 1997; West and Donaldson 2002) without any conclusion as to which would be more likely. Additional analysis into this topic would require a focused research study that would be able to provide conclusive inference into the specific effects of the WRAn for the years immediately following the event. Finally, as more sites are excavated in the fallout area of the WRAn, additional information will be assembled in order to analyze the trends occurring in the region. As few sites with limited investigation have been excavated in the region, it is difficult to fully comprehend the cultural effects that transpired immediately following the eruption and many years afterwards. As our understanding of prehistoric hunter-gather land use in Yukon and interior Alaska increases, so will our understanding of the short and long-term impact that this environmental disturbance had on the people and their ecosystems.

REFERENCES CITED

Abbott, M.B., Stafford, T.W., Jr., 1996. Radiocarbon Geochemistry of Modern and Ancient Arctic Lake. Quat. Res. 45, 300–311.

Ager, T.A., 1975. Late Quaternary Environmental History of the Tanana Valley, Alaska (PhD). Ohio State University.

Allan, T.E., 2018. Testing debitage typologies with statistical analysis: Experimental inferences upon archaeological material from FaPx-1, a sub-alpine hunting camp in the Alberta Rockies (No. Occasional Paper 38). Archaeological Survey of Alberta.

Allen, H.T., 1887. Report on the Expedition to the Copper, Tanana, and Koyukuk Rivers in the Territory of Alaska, in the Year 1885. Government Printing Office, Washington.

Allen, J.R.M., Huntley, B., 2018. Effects of tephra falls on vegetation: A Late-Quaternary record from southern Italy. J. Ecol. 106, 2456–2472.

Anderson, D.D., 1968. A Stone Age Campsite at the Gateway to America. Sci. Am. 218, 24–33.

Anderson, D.D., 1988. Onion Portage: The archaeology of a stratified site from the Kobuk River, Northwest Alaska. Anthropological Papers of the University of Alaska 22, 1–163.

Anderson, P.M., Edwards, M.E., Brubaker, L.B., 2004. Results and paleoclimate implications of 35 years of paleoecological research in Alaska. Developments in Quaternary Science 1, 427–440.

Andrefsky, W., 1994. Raw-Material Availability and the Organization of Technology. Am. Antiq. 59, 21–34.

Andrefsky, W., 2001. Lithic debitage: Context, form, meaning. University of Utah Press, Salt Lake City.

Andrefsky, W., 2008. Lithic technology: measures of production, use, and curation. Cambridge University Press, Cambridge.

Antos, J.A., Zobel, D.B., 2005. Plant responses in forests of the tephra-fall zone, in: Ecological Responses to the 1980 Eruption of Mount St. Helens. Springer, pp. 47–58.

Bamforth, D.B., 1986. Technological Efficiency and Tool Curation. Am. Antiq. 51, 38–50.

Barton, L., Shirar, S., Jordan, J.W., 2018. Holocene Human Occupation of the Central Alaska Peninsula. Radiocarbon 60, 367.

Berger, A.R., 1960. On a recent volcanic ash deposit, Yukon Territory, in: Proceedings of the Geological Association of Canada. Business & Economic Service Limited, pp. 117–118.

Bettinger, R.L., Garvey, R., Tushingham, S., 2015. Hunter-Gatherers: Archaeological and Evolutionary Theory. Springer.

Bigelow, N., 2014. The history of three lakes in interior Alaska. University of Alaska Fairbanks.

Bilderback, D.E., Slone, J.H., 1986. Persistence of Mount St. Helens ash on conifer foliage, in: Bilderback, D.E. (Ed.), Mount St. Helens 1980. Botanical Consequences of the Explosive Eruptions. University of California Press, Berkeley and Los Angeles, pp. 282–301.

Binford, L.R., 1978. Nunamiut: Ethnoarchaeology. Academic Press, New York.

Binford, L.R., 1979. Organization and Formation Processes: Looking at Curated Technologies. J. Anthropol. Res. 35, 255–273.

Binford, L.R., 1980. Willow Smoke and Dogs' Tails: Hunter-Gatherer Settlement Systems and Archaeological Site Formation. Am. Antiq. 45, 4–20.

Blaauw, M., 2010. Methods and code for "classical" age-modelling of radiocarbon sequences. Quat. Geochronol. 5, 512–518.

Blackford, J.J., Payne, R.J., Heggen, M.P., de la Riva Caballero, A., van der Plicht, J., 2014. Age and impacts of the caldera-forming Aniakchak II eruption in western Alaska. Quat. Res. 82, 85–95.

Blong, R., Enright, N., Grasso, P., 2017. Preservation of thin tephra. Journal of Applied Volcanology 6, 10.

Bostock, H.S., 1952. Geology of northwest Shakwak Valley, Yukon Territory. E. Cloutier, Queen's Printer.

Broughton, J.M., O'Connell, J.F., 1999. On Evolutionary Ecology, Selectionist Archaeology, and Behavioral Archaeology. Am. Antiq. 64, 153–165.

Brown, T.A., Nelson, D.E., Mathewes, R.W., Vogel, J.S., Southon, J.R., 1989. Radiocarbon dating of pollen by accelerator mass spectrometry. Quat. Res. 32, 205–212.

Case, M., 1986. Wild resource use in Northway, Alaska. US Fish and Wildlife.

Clague, J.J., Evans, S.G., Rampton, V.N., Woodsworth, G.J., 1995. Improved age estimates for the White River and Bridge River tephras, Western Canada. Can. J. Earth Sci. 32, 1172–1179.

Clark, D.W., 1991. Western subarctic prehistory. Hull, Quebec: Canadian Museum of Civilization.

Clark, J.L., 2017. The Howieson's Poort fauna from Sibudu Cave: Documenting continuity and change within Middle Stone Age industries. J. Hum. Evol. 107, 49–70.

Clark, J.L., Ligouis, B., 2010. Burned bone in the Howieson's Poort and post-Howieson's Poort Middle Stone Age deposits at Sibudu (South Africa): behavioral and taphonomic implications. J. Archaeol. Sci. 37, 2650–2661.

Coffman, S., Mills, R., Adams, J.S., 2015. Prehistoric Archaeological Survey in the Fortymile River Drainage, Alaska (No. Museum Technical Series Report #2015-06). University of Alaska Museum of the North.

Collins, W.B., Dale, B.W., Adams, L.G., Mcelwain, D.E., Joly, K., 2011. Fire, grazing history, lichen abundance, and winter distribution of caribou in Alaska's taiga. J. Wildl. Manage. 75, 369–377.

Corriveau, I., Hammer, T.J., 2002. Tro'chek and Forty Mile stone technology. Presented at the 29th Annual Meeting of the Alaska Anthropological Association, p. 11.

Crisafulli, C.M., MacMahon, J.A., Parmenter, R.R., 2005. Small-mammal survival and colonization on the Mount St. Helens volcano: 1980--2002, in: Ecological Responses to the 1980 Eruption of Mount St. Helens. Springer, pp. 199–218.

Crow, J.R., Obley, P.R., 1981. Hän, in: Helm, J. (Ed.), Handbook of North American Indians. Smithsonian Institution, Washington, pp. 506–513.

Dale, V.H., Denton, E.M., 2018. Plant Succession on the Mount St. Helens Debris-Avalanche Deposit and the Role of Non-native Species, in: Crisafulli, C.M., Dale, V.H. (Eds.), Ecological Responses at Mount St. Helens: Revisited 35 Years after the 1980 Eruption. Springer New York, New York, NY, pp. 149–164.

Dale, V.H., Swanson, F.J., Crisafulli, C.M., 2005. Disturbance, survival, and succession: understanding ecological responses to the 1980 eruption of Mount St. Helens, in: Ecological Responses to the 1980 Eruption of Mount St. Helens. Springer, pp. 3–11.

Davies, L.J., Jensen, B.J.L., Froese, D.G., Wallace, K.L., 2016. Late Pleistocene and Holocene tephrostratigraphy of interior Alaska and Yukon: Key beds and chronologies over the past 30,000 years. Quat. Sci. Rev. 146, 28–53.

Dawson, G.M., 1889. Report on an exploration in the Yukon District, etc, Annual Report, Geological Survey of Canada. Geological Survey of Canada, Montreal.

del Moral, R., Magnússon, B., 2014. Surtsey and Mount St. Helens: a comparison of early succession rates. Biogeosciences 11, 2099–2111.

Derry, D.E., 1975. Later Athapaskan prehistory: A migration hypothesis. West. Can. J. Anthropol. 5, 134–147.

Dixon, E.J., 1985. Cultural Chronology of Central Interior Alaska. Arctic Anthropol. 22, 47–66.

Domanski, M., Webb, J.A., 1992. Effect of heat treatment on siliceous rocks used in prehistoric lithic technology. J. Archaeol. Sci. 19, 601–614.

Dumond, D.E., 2004. Volcanism and History on the Northern Alaska Peninsula. Arctic Anthropol. 41, 112–125.

Dumond, D.E., 2011. Archaeology on the Alaska Peninsula: The Northern Section: Fifty Years Onward. Museum of Natural and Cultural History and Department of Anthropology, University of Oregon.

Dumond, D.E., Grayson, D.K., 1979. People and pumice on the Alaska Peninsula, in: Volcanic Activity and Human Ecology. Academic Press, pp. 373–392.

Easton, N.A., 2001. Intergenerational Differences in Ethnic Identification in a Northern Athapaskan Community. Am. Rev. Can. Stud. 31, 105–119.

Easton, N.A., 2014. Archaeological Excavations at the Little John Site (KdVo-6), Southwest Yukon Territory, Canada. Yukon College.

Esdale, J.A., 2008. A Current Synthesis of the Northern Archaic. Arctic Anthropol. 45, 3–38.

Faegri, K., Iversen, J., 1989. Textbook of Pollen Analysis, 4th Edition. John Wiley & Sons, Chichester.

Farnell, R., Hare, P.G., Blake, E., Bowyer, V., Schweger, C., Greer, S., Gotthardt, R., 2004. Multidisciplinary Investigations of Alpine Ice Patches in Southwest Yukon, Canada: Paleoenvironmental and Paleobiological Investigations. Arctic 57, 247–259.

Fernandez-Jalvo, Y., Andrews, P., 2016. Atlas of Taphonomic Identifications: 1001+ Images of Fossil and Recent Mammal Bone Modification. Springer.

Fitzhugh, B., 2012. Hazards, impacts, and resilience among hunter-gatherers of the Kuril Islands, in: Cooper, J., Sheets, P. (Eds.), Surviving Sudden Environmental Change. University of Colorado Press, Boulder, pp. 19–42.

Fitzhugh, B., Gjesfjeld, E., Brown, W., Hudson, M.J., Shaw, J.D., 2016. Resilience and the population history of the Kuril Islands, Northwest Pacific: A study in complex human ecodynamics. Quat. Int. 419, 165–193.

Flora of North America Association, n.d. Betula. Flora of North America Vol 3. http://www.efloras.org/ (accessed 1.10.20).

Friesen, T.M., 2001. A zooarchaeological signature for meat storage: re-thinking the drying utility index. Am. Antiq. 66, 315–331.

Gallant, A.L., Binnian, E.F., Omernik, J.M., Shasby, M.B., 1995. Ecoregions of Alaska (No. 1567). US Geology Survey Professional Paper.

Gates, M., 1994. Gold at Fortymile Creek: Early Days in the Yukon. UBC Press.

Gordon, B.C., 2012. The White River Ash fall: Migration trigger or localized event? Revista de Arqueología Americana 91–102.

Government of Canada. National Research Council Canada, 2012. Sunrise/sunset calculator - National Research Council Canada. https://www.nrc-cnrc.gc.ca/eng/services/sunrise/ (accessed 10.23.18).

Government of Yukon, 2019. Common Yukon Roadside Flowers.

Grattan, J., Torrence, R., 2010. Beyond gloom and doom: The long-term consequences of volcanic disasters, in: Grattan, J., Torrence, R. (Eds.), Living under the Shadow: Cultural Impacts of Volcanic Eruptions. Left Coast Press, pp. 1–18.

Grayson, D.K., Sheets, P.D., 1979. Volcanic disasters and the archaeological record, in: Volcanic Activity and Human Ecology. Academic Press, pp. 623–632.

Griggs, R.F., 1915. The effect of the eruption of Katmai on land vegetation. Bulletin of the American Geographical Society of New York (1901-1915) 47, 193.

Griggs, R.F., 1918. The Recovery of Vegetation at Kodiak (Part I in Series). The Ohio Journal of Science 19, 1–15.

Griggs, R.F., 1922. The Valley of Ten Thousand Smokes. National Geographic Society.

Grishin, S.Y., del Moral, R., Krestov, P.V., Verkholat, V.P., 1996. Succession following the catastrophic eruption of Ksudach volcano (Kamchatka, 1907). Vegetatio 127, 129–153.

Halpin, L., 1987. Living off the land: contemporary subsistence in Tetlin, Alaska. Alaska Department of Fish and Game, Division of Subsistence, Technical Paper.

Hammer, T.J., 1999. Preliminary Archaeological Testing and Survey of the Historic Site of Forty Mile. Yukon Government, Whitehorse.

Hammer, T.J., 2000. Forty Mile Archaeology Project, 1999. Yukon Government, Whitehorse.

Hammer, T.J., 2001. Forty Mile Archaeology Project, 2000. Yukon Government, Whitehorse.

Hammer, T.J., 2002a. The Forty Mile Archaeology Project, 2001. Yukon Government, Whitehorse.

Hammer, T.J., 2002b. The Forty Mile Archaeology Project, 2002: Preliminary Report. Yukon Government, Whitehorse.

Hammer, T.J., Thomas, C.D., 2006. Archaeology at Forty Mile/ Ch'ëdä Dëk. Yukon Government.

Hanson, L.W., 1965. Size distribution of the White River ash, Yukon Territory. University of Alberta.

Hare, P.G., 1995. Holocene Occupations in the Southern Yukon - New Perspectives from the Annie Lake Site (Masters). University of Alberta.

Hare, P.G., Greer, S., Gotthardt, R., Farnell, R., Bowyer, V., Schweger, C., Strand, D., 2004. Ethnographic and Archaeological Investigations of Alpine Ice Patches in Southwest Yukon, Canada. Arctic 57, 260–272.

Hare, P.G., Hammer, T.J., Gotthardt, R.M., 2008. The Yukon projectile database. Projectile point sequences in northwestern North America. Publication 321–332.

Hare, P.G., Thomas, C.D., Topper, T.N., Gotthardt, R.M., 2012. The Archaeology of Yukon Ice Patches: New Artifacts, Observations, and Insights. Arctic 65, 118–135.

Haynes, T.L., Simeone, W.E., 2007. Upper Tanana Ethnographic Overview and Assessment, Wrangell St. Elias National Park and Preserve. Alaska Department of Fish and Game, Division of Subsistence.

Heffner, T., 2002. KaVn-2: An Eastern Beringian Tradition archaeological site in west-central Yukon Territory, Canada. Heritage Branch Government of the Yukon Hude Hudän Series, Occasional Papers in Archaeology.

Hinckley, T.M., Imoto, H., Lee, K., Lacker, S., Morikawa, Y., Vogt, K.A., Grier, C.C., Keyes, M.R., Teskey, R.O., Seymour, V., 1984. Impact of tephra deposition on growth in conifers: the year of the eruption. Can. J. For. Res. 14, 731–739.

Hoffman, S.M., 1999. After Atlas shrugs: cultural change or persistence after a disaster, in: Smith, A.O., Hoffman, S.M. (Eds.), The Angry Earth:Disaster in Anthropological Perspective. Routledge, New York, pp. 302–326.

Hoffman, S.M., Oliver-Smith, A., 1999. Anthropology and the Angry Earth: An Overview, in: Hoffman, S.M., Oliver-Smith, A. (Eds.), The Angry Earth: Disaster in Anthropological Perspective. Routledge, New York, pp. 302–326.

Hosley, E.H., 1981. Environment and culture in the Alaska Plateau, in: Helm, J. (Ed.), Handbook of North American Indians. Smithsonian Institution, Washington, pp. 533–545.

Hotes, S., Poschlod, P., Takahashi, H., Grootjans, A.P., Adema, E., 2004. Effects of tephra deposition on mire vegetation: a field experiment in Hokkaido, Japan. J. Ecol. 92, 624–634.

Hultén, E., 1968. Flora of Alaska and Neighboring Territories: A Manual of the Vascular Plants. Stanford University Press.

Idaho Virtual Museum, Version 4.1.0. Online database. https://virtual.imnh.iri.isu.edu (accessed 9.1.17).

Jacobson, G.L., Jr., Bradshaw, R.H.W., 1981. The Selection of Sites for Paleovegetational Studies. Quat. Res. 16, 80–96.

Jagger, T.A., 1945. Volcanoes Declare war: Logistics and Strategy of Pacific Volcano Science. Honolulu, HI, Paradise Pacific Ltd.

Jensen, B.J.L., Pyne-O'Donnell, S., Plunkett, G., Froese, D.G., Hughes, P.D.M., Sigl, M., McConnell, J.R., Amesbury, M.J., Blackwell, P.G., van den Bogaard, C., Buck, C.E., Charman, D.J., Clague, J.J., Hall, V.A., Koch, J., Mackay, H., Mallon, G., McColl, L., Pilcher, J.R., 2014. Transatlantic distribution of the Alaskan White River Ash. Geology 42, 875–878.

Jeske, R.J., Lurie, R., 1993. The archaeological visibility of bipolar technology: An example of the Koster Site. MidCont. J. Archaeol. 18, 131–160.

Kelly, R.L., 1983. Hunter-Gatherer Mobility Strategies. J. Anthropol. Res. 39, 277–306.

Kelly, R.L., 1988. The Three Sides of a Biface. Am. Antiq. 53, 717–734.

Kelly, R.L., 2000. Elements of a behavioral ecological paradigm for the study of prehistoric hunter-gatherers. Social Theory in Archaeology, University of Utah Press, Salt Lake City 63–78.

Klein, R.G., 1989. Why does skeletal part representation differ between smaller and larger bovids at klasies river mouth and other archeological sites? J. Archaeol. Sci. 16, 363–381.

Krauss, Michael, Gary Holton, Jim Kerr, and Colin T. West, 2011. Indigenous Peoples and Languages of Alaska.

Kuhn, T.S., McFarlane, K.A., Groves, P., Mooers, A.Ø., Shapiro, B., 2010. Modern and ancient DNA reveal recent partial replacement of caribou in the southwest Yukon. Mol. Ecol. 19, 1312–1323.

Le Blanc, R.J., 1984. The Rat Indian Creek site and the late prehistoric period in the interior northern Yukon. National Museum of Man. Mercury Series. Archaeology Survey of Canada. Ottawa 1–504.

Lerbekmo, J.F.L., 2008. The White River Ash: largest Holocene Plinian tephra. Can. J. Earth Sci. 45, 693–700.

Lerbekmo, J.F., Campbell, F.A., 1969. Distribution, composition, and source of the White River Ash, Yukon Territory. Can. J. Earth Sci. 6, 109–116.

Lerbekmo, J.F., Westgate, J.A., Smith, D.G.W., Denton, G.H., 1975. New data on the character and history of the White River volcanic eruption, Alaska. Quaternary Studies 203–209.

Lyman, L.R., 1994. Vertebrate Taphonomy. Cambridge University Press.

Lynch, J.J., Goebel, T., Graf, K.E., Rasic, J.T., Kuehn, S.C., 2018. Archaeology of the uppermost Tanana basin: Results of a survey of the Nabesna and Chisana Rivers, East-central Alaska. Alaska Journal of Anthropology 16, 21.

MacIntosh, G.D., 1997. Calendric Dating and Seasonality of the White River Ash. University of Alaska Fairbanks.

MacMahon, J.A., Parmenter, R.R., Johnson, K.A., Crisafulli, C.M., 1989. Small Mammal Recolonization on the Mount St. Helens Volcano: 1980-1987. Am. Midl. Nat. 122, 365–387.

MacNeish, R.S., 1964. Investigations in Southwest Yukon: Archaeological Excavations Comparisons, and Speculations. Phillips Academy, The Foundation.

Malde, H.E., 1964. Ecological significance of some unfamiliar geologic processes. Ft. Burgwin Res. Center. Rancho de Taos, N. Mex 3, 89.

Mason, O.K., Bigelow, N.H., 2008. The Crucible of Early to Mid-Holocene Climate in Northern Alaska: Does Northern Archaic Represent the People of the Spreading Forest? Arctic Anthropol. 45, 39–70.

McClellan, C., 1975. My old people say: An ethnographic survey of southern Yukon Territory. National Museum of Man; available from National Museums of Canada.

McClellan, C., 1981. Tutchone, in: Helm, J. (Ed.), Handbook of North American Indians. Smithsonian Institution, Washington, pp. 493–505.

McCook, L.J., 1994. Understanding Ecological Community Succession: Causal Models and Theories, a Review. Vegetatio 110, 115–147.

McGimsey, R.G., Richter, D.H., DuBois, G.D., Miller, T.P., 1992. A postulated new source for the White River Ash, Alaska. Geologic studies in Alaska. US. Geological Survey 212–218.

McKennan, R.A., 1959. The Upper Tanana Indians, Yale University Publications in Anthropology. Yale University, New Haven.

McKennan, R.A., 1969. Athapaskan Groups of Central Alaska at the Time of White Contact. Ethnohistory 16, 335–343.

McKennan, R.A., 1981. Tanana, in: Helm, J. (Ed.), Handbook of North American Indians. Smithsonian Institution, Washington, pp. 562–576.

Mercieca, A., Hiscock, P., 2008. Experimental insights into alternative strategies of lithic heat treatment. J. Archaeol. Sci. 35, 2634–2639.

Mishler, C., Simeone, W.E., 2004. Hän, people of the river: Hän hwëch'in: an ethnography and ethnohistory. Univ of Alaska Pr, Fairbanks.

Moodie, D.W., Catchpole, A.J.W., Abel, K., 1992. Northern Athapaskan Oral Traditions and the White River Volcano. Ethnohistory 39, 148–171.

Moore, P.D., Webb, J.A., Collison, M.E., Others, 1991. Pollen analysis. Blackwell scientific publications.

Morin, E., 2007/1. Fat composition and Nunamiut decision-making: a new look at the marrow and bone grease indices. J. Archaeol. Sci. 34, 69–82.

Mullen, P.O., 2012. An Archaeological Test of the Effects of the White River Ash Eruptions. Arctic Anthropol. 49, 35–44.

Mulliken, K.M., 2016. Holocene Volcanism and Human Occupation in the Middle Susitna River Valley, Alaska (Master of Arts). University of Alaska Fairbanks.

Mulliken, K.M., Schaefer, J.R., Cameron, C.E., 2018. Geospatial distribution of tephra fall in Alaska: a geodatabase compilation of published tephra fall occurrences from the Pleistocene to the present: Alaska Division of Geological & Geophysical Surveys Miscellaneous Publication 164, 46 p.

Nelson, J.L., Zavaleta, E.S., Chapin, F.S., 2008. Boreal Fire Effects on Subsistence Resources in Alaska and Adjacent Canada. Ecosystems 11, 156–171.

Nienstaedt, H., and Zasada, J. C., 1990. Picea glauca (Moench) Voss, in: Burns, R.M., Honkala, B.H. (Eds.), Silvics of North America, Handbook 654. U. S. Dept. of Agriculture, Washington, pp. 204–226.

Oliver-Smith, A., Hoffman, S.M., 1999. The angry earth: disaster in anthropological perspective. Psychology Press.

Osgood, C., 1971. The Han Indians: A compilation of ethnographic and historical data on the Alaska-Yukon boundary area. New Haven: Department of Anthropology, Yale University.

Oswald, E.T., Brown, B.N., 1990. Vegetation establishment during 5 years following wildfire in northern British Columbia and southern Yukon Territory (No. Information Report BC-X-320). Forestry Canada.

Outram, A.K., 2001. A New Approach to Identifying Bone Marrow and Grease Exploitation: Why the "Indeterminate" Fragments should not be Ignored. J. Archaeol. Sci. 28, 401–410.

Payne, R., Blackford, J., 2008. Distal volcanic impacts on peatlands: palaeoecological evidence from Alaska. Quat. Sci. Rev. 27, 2012–2030.

Pike-Tay, A., Cosgrove, R., 2002. From Reindeer to Wallaby: Recovering Patterns of Seasonality, Mobility, and Prey Selection in the Palaeolithic Old World. Journal of Archaeological Method and Theory 9, 101–146.

Pollock, J., Newton, B., 1980. Preliminary field report on the results of the magnetometer survey, test excavation and artifact collection around specific structures at Fort Selkirk and Forty Mile, Yukon Territory. Canada-Yukon Territory Tourism, Whitehorse.

Potter, B.A., 2008a. A First Approximation of Holocene Inter-Assemblage Variability in Central Alaska. Arctic Anthropol. 45, 89–113.

Potter, B.A., 2008b. Exploratory Models of Intersite Variability in Mid to Late Holocene Central Alaska. Arctic 61, 407–425.

Preece, S.J., McGimsey, R.G., Westgate, J.A., Pearce, N.J.G., Hart, W.K., Perkins, W.T., 2014. Chemical complexity and source of the White River Ash, Alaska and Yukon. Geosphere 10, 1020–1042.

Prentiss, W.C., 1998. The Reliability and Validity of a Lithic Debitage Typology: Implications for Archaeological Interpretation. Am. Antiq. 63, 635–650.

Ramsey, C.B., 2009. Bayesian Analysis of Radiocarbon Dates. Radiocarbon 51, 337–360.

Rasic, J.T., 2011. Functional variability in the late Pleistocene archaeological record of eastern Beringia: a model of late Pleistocene land use and technology from northwest Alaska, in: From the Yenisei to the Yukon: Interpreting Lithic Assemblage Variability in Late Pleistocene/Early Holocene Beringia. Texas A&M University Press College Station, pp. 128–164.

Rasic, J.T., 2017. Personal communication. US National Park Service.

Reimer, P.J., Bard, E., Bayliss, A., Warren Beck, J., Blackwell, P.G., Ramsey, C.B., Buck, C.E., Cheng, H., Lawrence Edwards, R., Friedrich, M., Grootes, P.M., Guilderson, T.P., Haflidason, H., Hajdas, I., Hatté, C., Heaton, T.J., Hoffmann, D.L., Hogg, A.G., Hughen, K.A., Felix Kaiser, K., Kromer, B., Manning, S.W., Niu, M., Reimer, R.W., Richards, D.A., Marian Scott, E., Southon, J.R., Richard A Staff, Turney, C.S.M., van der Plicht, J., 2013. IntCal13 and Marine13 Radiocarbon Age Calibration Curves 0–50,000 Years cal BP. Radiocarbon 55, 1869–1887.

Reimer, P.J., Reimer, R.W., Blaauw, M., 2013. Radiocarbon Dating; Calibration of the 14C Record, in: Elias, S.A., Mock, C.J. (Eds.), Encyclopedia of Quaternary Science (Second Edition). Elsevier, Amsterdam, pp. 345–352.

Reitz, E.J., Reitz, E., Wing, E.S., 1999. Zooarchaeology. Cambridge University Press.

Reuther, J., Potter, B., Coffman, S., Smith, H., Bigelow, N., 2019. Revisiting the timing of the northern lobe of the White River Ash volcanic event in eastern Alaska and western Yukon. Radiocarbon 62(1): 169–188.

Reuther, J.D., Slobodina, N.S., Rasic, J.T., Cook, J.P., Speakman, R.J., 2011. Gaining momentum: Late Pleistocene and early Holocene archaeological obsidian source studies in interior and northeastern Beringia, in: Ted Goebel, I.B. (Ed.), From the Yenisei to the Yukon Interpreting Lithic Assemblage Variability in Late Pleistocene/Early Holocene Beringia. Texas A&M University Press College Station, pp. 270–286.

Richter, D.H., Preece, S.J., Mcgimsey, R.G., Westgate, J.A., 1995. Mount Churchill, Alaska: source of the late Holocene White River Ash. Can. J. Earth Sci. 32, 741–748.

Riehle, J.R., Dumond, D.E., Meyer, C.E., Schaaf, J.M., 2000. Tephrochronology of the Brooks River Archaeological District, Katmai National Park and Preserve, Alaska: what can and cannot be done with tephra deposits. Geological Society, London, Special Publications 171, 245–266.

Robinson, S.D., 2001. Extending the Late Holocene White River Ash Distribution, Northwestern Canada. Arctic 54, 157–161.

Sarna-Wojcicki, A., 2000. Tephrochronology, in: Quaternary Geochronology. American Geophysical Union, pp. 357–377.

Schmitter, F., 1910. Upper Yukon native customs and folk-lore (No. 4). Smithsonian institution.

Schwatka, F., 1900. A Reconnaissance of the Yukon Valley, 1883:, Compilations of narratives of explorations in Alaska. United States Government Printing Office, Washington, DC.

Seppä, H., 2007. Pollen Analysis Principles. Encyclopedia of Quaternary Science.

Sheets, P., 2001. The effects of explosive volcanism on simple to complex societies in ancient middle America. Interhemispheric Climate Linkages. Academic Press, San Diego 73–86.

Sheppard, W.L., Steffian, A.F., Staley, D.P., Bigelow, N.H., 1991. Late Holocene occupations at the Terrace site, Tok, Alaska. Report prepared for US Air Force, Electronic Systems Division. Anchorage: Arctic Environmental Information and Data Center, University of Alaska.

Shinkwin, A.D., Aigner, J.S., Andrews, E.F., 1980. Land Use Patterns in the Upper Tanana Valley, Alaska. Anthropological Papers of the University of Alaska 19, 45–53.

Smith, C. A. S., Meikle J. C., Roots C. F. (Ed.), 2004. Ecoregions of the Yukon Territory: Biophysical properties of Yukon landscapes, PARC Technical Bulletin No. 04-01. Agriculture and Agri-food Canada, Summerland, BC.

Smith, C.A.S., Ping, C.L., Fox, C.A., Kodama, H., 1999. Weathering characteristics of some soils formed in White River Tephra, Yukon Territory, Canada. Can. J. Soil Sci. 79, 603–613.

Smith, C.S., 2003/6. Hunter–gatherer mobility, storage, and houses in a marginal environment: an example from the mid-Holocene of Wyoming. Journal of Anthropological Archaeology 22, 162–189.

Smith, E.A., Winterhalder, B., 1992. Evolutionary Ecology and Human Behavior. Transaction Publishers.

Stuiver, M., Reimer, P.J., and Reimer, R.W., 2013. CALIB Radiocarbon Calibration Version 7.0.4. http://calib.org/calib/ (accessed 3.1.17).

Sullivan, A.P., Rozen, K.C., 1985. Debitage Analysis and Archaeological Interpretation. Am. Antiq. 50, 755–779.

Swanson, F.J., Crisafulli, C.M., 2018. Volcano Ecology: State of the Field and Contributions of Mount St. Helens Research, in: Crisafulli, C.M., Dale, V.H. (Eds.), Ecological Responses at Mount St. Helens: Revisited 35 Years after the 1980 Eruption. Springer New York, New York, NY, pp. 305–323.

Thomas, C.D., 2003. Ta'Tla mun : an archaeological examination of technology, subsistence economy and trade at Tatlmain Lake, Central Yukon (Master of Arts). University of Alberta.

Thomas, C.D., 2004. Forty Mile Archaeological Impact Assessment 2003. Yukon Government, Whitehorse.

Thomas, C.D., 2005. Forty Mile Archaeological Impact Assessment 2004. Yukon Government, Whitehorse.

Thomas, C.D., 2006. Forty Mile Archaeology 2005. Yukon Government, Whitehorse.

Thomas, C.D., 2018. Personal communication. Yukon Government.

Thomas, D.H., 1969. Great Basin Hunting Patterns: A Quantitative Method for Treating Faunal Remains. Am. Antiq. 34, 392–401.

Torrence, R., 2016. Social resilience and long-term adaptation to volcanic disasters: The archaeology of continuity and innovation in the Willaumez Peninsula, Papua New Guinea. Quat. Int. 394, 6–16.

Tr'ondëk Hwëch'in, 2015. http://www.trondek.ca/aboutus.php (accessed 10.27.19).

Trowbridge, T., 1976. Aniakchak Crater. Alaska Geographic 4, 71–73.

US Department of Commerce, NOAA, Earth System Research Laboratory, 2005. ESRL Global Monitoring Division - Global Radiation Group. https://www.esrl.noaa.gov/gmd/grad/solcalc/ (accessed 10.23.18).

Vandergoes, M.J., Prior, C.A., 2003. AMS Dating of Pollen Concentrates—A Methodological Study of Late Quaternary Sediments from South Westland, New Zealand. Radiocarbon 45, 479–491.

VanderHoek, R., 2010. The role of ecological barriers in the development of cultural boundaries during the later Holocene of the central Alaska peninsula. University of Illinois at Urbana-Champaign.

VanderHoek, R., and Nelson, R.E., 2007. Ecological roadblocks on a constrained landscape: The cultural effects of catastrophic volcanism on the Alaska Peninsula, southwest Alaska, in: J. Gero, M. Leone, and R. Torrence (Ed.), Living under the Shadow: Cultural Impacts of Volcanic Eruptions. Left Coast Press, New York, pp. 133–152.

VanderHoek, R., Nelson, R.E., 2010. Ecological Roadblocks on a Constrained Landscape: Cultural Effects of Catastrophic Holocene Volcanism on the Alaska Peninsula, Southwest Alaska, in: Grattan, J., Torrence, R. (Eds.), Living under the Shadow: Cultural Impacts of Volcanic Eruptions. Left Coast Press, pp. 133–152.

Wahl, H.E., Fraser, D.B., Harvey, R.C., Maxwell, J.B., 1987. Climate of Yukon (No. 40 Climatological studies). Environment Canada.

Walker, G.P.L., 1973. Explosive volcanic eruptions—a new classification scheme. Geol. Rundsch. 62, 431–446.

Waythomas, C.F., 2015. Geomorphic consequences of volcanic eruptions in Alaska: A review. Geomorphology 246, 123–145.

West, K.D., Donaldson, J.A., 2002. Resedimentation of the late Holocene White River tephra, Yukon Territory and Alaska. Yukon Exploration and Geology 239–247.

White River First Nation, 2013. https://whiteriverfirstnation.com/background/ (accessed 10.23.18).

Wilson, L., 1976. Explosive Volcanic Eruptions—III. Plinian Eruption Columns. Geophys. J. Int. 45, 543–556.

Winterhalder, B., 2001. The behavioural ecology of hunter gatherers, in: C. Panter-Brick, R. H. Layton, and P. Rowley-Conwy (Ed.), Hunter-Gatherers: An Interdisciplinary Perspective. Cambridge University Press, Cambridge , pp. 12–38.

Wong, J., 2018. Edmonton elm trees stressed by fast switch from winter to summer. Global News. https://globalnews.ca/news/4249389/edmonton-elm-trees-stressed-by-fast-switch-from-winter-to-summer/ (accessed 4.1.19).

Workman, W.B., 1974. First Dated Traces of Early Holocene Man in the Southwest Yukon Territory, Canada. Arctic Anthropol. 11, 94–103.

Workman, W.B., 1978. Prehistory of the Aishihik-Kluane Area, Southwest Yukon Territory. National Museum of Man. Mercury Series. Archaeology Survey of Canada. Ottawa.

Workman, W.B., 1979. The significance of volcanism in the prehistory of subarctic northwest North America. Volcanic activity and human ecology 339–371.

Yeshurun, R., Marom, N., Bar-Oz, G., 2007. Differential fragmentation of different ungulate body-size: a comparison of gazelle and fallow deer bone fragmentation in Levantine prehistoric assemblages. Journal of Taphonomy 5, 137–148.

Zasada J. C. and Phipps, H. M., 1990. Populus balsamifera L, in: Burns, R.M., Honkala, B.H. (Eds.), Silvics of North America, Handbook 654. U. S. Dept. of Agriculture, Washington.

Zobel, D.B., Antos, J.A., 1997. A Decade of Recovery of understory Vegetation Buried by Volcanic Tephra from Mount St. Helens. Ecol. Monogr. 67, 317–344.

Zobel, D.B., Antos, J.A., 2018. Forest Understory Buried by Volcanic Tephra: Inertia, Resilience, and the Pattern of Community Redevelopment, in: Crisafulli, C.M., Dale, V.H. (Eds.), Ecological Responses at Mount St. Helens: Revisited 35 Years after the 1980 Eruption. Springer New York, New York, NY, pp. 113–125.

APPENDIX A: POLLEN SAMPLE PROCESSING SHEETS

SITE: 6 Mile Lake CORE: 10-C PROCESSED BY: DHB

Tube #	1	2	3	4	5	6	7	8	DATE	REMARKS
Sample name/depth (cm/m)	D1 18.75-19	D1 19-19.25	D1 19.25-19.50	D1 19.50 19.75	D1 19.75-20.0	D1 21-21.5	D1 21.5-22	D1 22-22.5		
Lab #	17-001	17-002	17-003	17-004	17-005	17-006	17-007	17-008	6/6/17	started w/ 15ml glass conic.
Sample size(cc/ml/g)	0.1	0.2	0.1	0.2	0.2	0.2	0.6	0.6	"	1-5 are roughly the same size 6-8 "
__ Lyc. tabs + HCl Tabs	no 1	fizz 1	1	1	1	1	2	2	"	Lycopodium batch no.: Grains per tablet: prob 0.4 or 0.6
H2O Wash ~~sieve~~ (not seived)	✓							→	"	
KOH/NaOH boil soak(7 min.)	✓ D. brown		l-tan			d. Brown		→	"	
H2O wash 3 X	✓							→	"	
10% HCl wash	✓							→		
HF Cold 17 hrs Hot __ min/hrs@__°C	✓							→		shift to 15 ml plastic conic, in@ 4pm out @ 9 a
Hot HCl @ 60-70c (25 min 1 X)	✓							→	6/7/17	
Heavy Liquids s.g.___ (~~5 min~~ @ full RPM)										
~~HF~~ __mins/hrs										
~~Hot HCl temp~~ ___ ___ ~~min~~ ___ x										
~~Pyro~~ hot (15 min.)										
~~Nitex~~										
H2O wash	✓							→	"	shift to glass tube on 2nd wash
Glacial acetic wash 1 x	✓								"	#3-5 are very small, may disappear w/acetolysis
Acetolysis boil 40 seconds ~~minutes~~	✓							→	"	
Glacial acetic wash 1x	✓							→	"	
H2O wash 3X ~~pH check~~ III	✓							→	"	
~~Safranin stain~~ (___% ~~aqueous~~)										
TBA wash 1x	✓							→	"	
TBA transfer Samples split: yes/no	✓							→	"	
Silicon oil	✓							→	"	

SITE: 6 Mile Lake CORE: 10-C PROCESSED BY: NHB

Tube #	1	2	3	4	5	6	7	8	DATE	REMARKS
Sample name/depth (cm/m)	D1 17.25-17.50	D1 17.50-17.75	D1 17.75-18.00	D1 18.00-18.25	D1 18.25-18.50	D1 18.50-18.75	D1 22.5-23.0	D1 24-24.5		
Lab #	17-009	17-010	17-011	17-012	17-013	17-014	17-015	17-016	6/9/17	
Sample size(cc/ml/g)	0.4	0.4	0.3	0.4	0.4	0.4	0.6	0.4	"	
3 Lyc. tabs + HCl	No fizz							→	"	Lycopodium batch no.: 3862 Grains per tablet: 9660
H2O Wash 11 ~~µ sieve~~	√							→	"	after 3rd wash
KOH/NaOH boil soak(8 min.)	brown							→	6/12	
H2O wash 3 x 111	√							→	"	
10% HCl wash	√							→	"	
HF: Cold 4 hrs. Hot ___ min/hrs@__°C	√							→	"	in at Noon, out at 4pm
Hot HCl 60-70 20 min 1 X)	√							→		
~~Heavy Liquids s.g.~~ (5 min. @ full RPM)										
~~HF ___mins/hrs~~										
Hot HCl temp ___ ___ min ___ x										
~~Pyro hot (15 min.)~~										
~~Nitex~~										
H2O wash 111	√							→	6/12	Transf to glass on 2nd wash Sat on bench in H2O til the 19th
Glacial acetic wash 1 x	√							→	6/19	
Acetolysis 1 minutes	√							→	"	
Glacial acetic wash	Clumpy							→	"	#1,2 especially clumped
H2O wash 3X pH check 11 1	√							→	"	
~~Safranin stain (___% aqueous)~~										
TBA wash	√							→	"	
TBA transfer Samples split: yes/no	√							→	"	
Silicon oil	√							→	"	

APPENDIX B: RADIOCARBON DATES - POLLEN SAMPLES

The University of Georgia

Center for Applied Isotope Studies

RADIOCARBON ANALYSIS REPORT

January 23, 2018

Holly A. Smith
University of Alaska Fairbanks
Anthropology Dept.
1790 Tanana Loop. Bunnell 405A
Fairbanks, AK 99775-7720
Fairbanks, AK 99775-5860

Dear Ms. Smith

Enclosed please find the results of ^{14}C Radiocarbon analyses and Stable Isotope Ratio $\delta^{13}C$ analyses for the samples received by our laboratory on January 3, 2018.

UGAMS#	Sample ID	Material	$\delta^{13}C$,‰	^{14}C age, years BP	±	pMC	±
32636	6mile_10C_D1:13-15	pollen	-30.18	2090	25	77.1	0.22
32637	6mile_10C_D1:20.5-22.5	pollen	-29.70	n/a		n/a	
32638	6mile_10C_D1:29-30	pollen+	-28.60	2630	30	72.04	0.28
32639	6mile_10C_D1:79-81	pollen+	-28.39	3400	30	65.51	0.21

Pollen + - it is a combined sample of pollen and micro plant fragments.

The pollen sample was collected on fiberglass filter, then was treated with 1N HCl to remove any carbonates, after that the samples was filtered on fiberglass filter, washed with deionized water and dried at 60°C. For accelerator mass spectrometry analysis the cleaned samples were combusted at 900°C in evacuated / sealed ampoules in the presence of CuO. The resulting carbon dioxide was cryogenically purified from the other reaction products and catalytically converted to graphite using the method of Vogel *et al.* (1984) Nuclear Instruments and Methods in Physics Research B5, 289-293. Graphite $^{14}C/^{13}C$ ratios were measured using the CAIS 0.5 MeV accelerator mass spectrometer. The sample ratios were compared to the ratio measured from the Oxalic Acid I (NBS SRM 4990). The sample $^{13}C/^{12}C$ ratios and $^{15}N/^{14}N$ were measured separately using EA-MS system and expressed as $\delta^{13}C$ with respect to PDB and $\delta^{15}N$ with respect to air with an error of less than 0.1‰.

ilac-MRA PJLA Testing Accreditation No.67144

ISO/IEC 17025:2005

Sincerely,

Alexander Cherkinsky, Ph.D.
Senior Research Scientist

120 Riverbend Road • Athens, Georgia 30602-4702
Telephone 706-542-1395 • Fax 706-542-6106 • www.cais.uga.edu
An Equal Opportunity/Affirmative Action Institution

The University of Georgia

Center for Applied Isotope Studies

RADIOCARBON ANALYSIS REPORT

February 26, 2018

Holly A. Smith
University of Alaska Fairbanks
Anthropology Dept.
1790 Tanana Loop. Bunnell 405A
Fairbanks, AK 99775-7720
Fairbanks, AK 99775-5860

Dear Ms. Smith

Enclosed please find the results of ^{14}C Radiocarbon analyses and Stable Isotope Ratio $\delta^{13}C$ analyses for the samples received by our laboratory on February 12, 2018.

UGAMS#	Sample ID	Material	$\delta^{13}C$,‰	^{14}C age, years BP	±	pMC	±
33332	6mile_10C_Surf.:68-70	plant fragm	-25.92	2490	25	73.31	0.21

The plant fragments sample was treated with 5% HCl at the temperature 80°C for 1 hour, then they was washed and with deionized water on the fiberglass filter and rinsed with diluted NaOH to remove possible contamination by humic acids. After that it was treated with diluted HCL again, washed with deionized water and dried at 60°C

For accelerator mass spectrometry analysis the cleaned samples were combusted at 900°C in evacuated / sealed ampoules in the presence of CuO.

The resulting carbon dioxide was cryogenically purified from the other reaction products and catalytically converted to graphite using the method of Vogel *et al.* (1984) Nuclear Instruments and Methods in Physics Research B5, 289-293. Graphite $^{14}C/^{13}C$ ratios were measured using the CAIS 0.5 MeV accelerator mass spectrometer. The sample ratios were compared to the ratio measured from the Oxalic Acid I (NBS SRM 4990). The sample $^{13}C/^{12}C$ ratios and $^{15}N/^{14}N$ were measured separately using EA-MS system and expressed as $\delta^{13}C$ with respect to PDB and $\delta^{15}N$ with respect to air with an error of less than 0.1‰.

ISO/IEC 17025:2005

Sincerely,

Alexander Cherkinsky, Ph.D.
Senior Research Scientist

120 Riverbend Road • Athens, Georgia 30602-4702
Telephone 706-542-1395 • Fax 706-542-6106 • www.cais.uga.edu
An Equal Opportunity/Affirmative Action Institution

Table 1: Radiocarbon dates from 6 Mile Lake

Laboratory #	Core	Drive	Depth in drive (cm)	Depth (cm) from sediment/water interface	Material Dated	Age (^{14}C yr BP)	Age Error (1 SD)	Calibrated Age (median)	δ^{13}C (‰)
OS-89977	09B	D3	19-21	191-193	Seeds (Carex, Cyperaceae, Potamogeton)	8,100	50	9,041	-26.21
OS-106818	10C	D2	69-70	240-241	Herbaceous fragments	5,580	30	6,358	-25.28
OS-106642	10C	D3	36-37	300-301	Moss	6,690	40	7,561	-34.6
OS-106615	10C	D3	83-85[1]	348-350	Wood	8,780	45	9,795	-26.55
OS-106819	10C	D3	83-85[1]	348-350	Moss & herbaceous fragments	8,870	35	10,023	-22.59
OS-106820	10C	D4	10-12	369-371	Eleocharis seed & leaves	9,170	35	10,326	-26.56
OS-89855	10C	D4	19-20[2]	378-379	Seeds (Potamogeton, Eleocharis, Mentha, Ranunculus) & Graminoid leaf fragments.	12,300	50	14,224	-12.96
OS-89982	10C	D4	46-47	405-406	Terrestrial leaves and seeds	9,430	45	10,662	-27.73
OS-89856	10D	D1	86-88[3]	127-129	Seeds (Nuphar & Potentilla)	2,510	30	2,587	-27
OS-89858	10D	D1	86-88[3]	127-129	Wood	2,730	25	2,820	-27.19
OS-89957	10D	D3	39-41[4]	251-253	Graminoid fragments	5,580	30	6,358	-19.68
OS-89986	10D	D3	39-41[4]	251-253	Seeds (Najas, Potamogeton, Potentilla, Cyperaceae, Betulaceae)	5,400	35	6,225	-22.34
OS-89958	10D	D3	39-41[4]	251-253	Moss	5,520	35	6,316	-37.06
OS-89959	10D	D5	14-16	390-392	Seeds (Carex)	9,810	45	11,226	-26.49
OS-106614	10F	Surf1	54-56	42-44	Nuphar seed	2,530	30	2,618	-27.18
OS-106817	10F	D1	24-25[2]	68-69	Moss	6,720	30	7,587	-44.07
OS-106816	10F	D3	10-12	147-149	Seeds (Carex, Mentha) & 1 Picea needle tip	8,620	40	9,576	-27

[1] These dates were averaged in the chronology.
[2] These dates were not used in the chronology (see text for explanation).
[3] These dates were averaged in the chronology.
[4] These dates were averaged in the chronology.

Table 2: Calibrated dates and tie points used in age models for 6 Mile Lake.

Core	Depth (cm) below sediment/water interface	Calibrated age	Comment	Slope	Intercept	Sedimentation rate (mm/10yr)
09-B	0	0	Sed/water interface			
	30	1835	WRAn	61.16667	0.0000	1.634877
	192	9041		44.48148	500.5556	2.248127
10-C	0	0	Sed/water interface			
	95	1835	WRAn	19.3684	0.0000	5.1630
	240.5	6358		31.0515	-1109.8969	3.2205
	301.5	7561		19.7213	1615.0246	5.0707
	349	9881	Average 2 dates	48.8421	-7164.8947	2.0474
	370	10326		21.1905	2485.5238	4.7191
	405.5	10662		9.4648	6824.0282	10.5655
10-D	0	0	Sed/water interface			
	94	1835	WRAn	19.52128	0	5.122616
	128	2703	Average 2 dates	25.52941	-564.765	3.917051
	252	6300	Average 3 dates	29.00806	-1010.03	3.447317
	391	11226		35.43885	-2630.59	2.821762
10-F	0	0	Sed/water interface			
	26	1835	WRAn	70.57692	0	1.416894
	43	2618		46.05882	637.4706	2.171137
	148	9576		66.26667	-231.467	1.509054

APPENDIX C: AGE MODEL SETTINGS

Settings (square brackets give names of the constants)

Calibration curve: IntCal13.14C
Age-depth model: polynomial regression [type=2] of order 2 [smooth]
Weighted by the calibrated probabilities [wghts=1]
Calculations at 95% confidence ranges [prob=0.95]
Amount of iterations: 1000 [its]
Calendar age point estimates for depths based on weighted average of all age-depth curves [est=1]
Calendar scale used: cal BP [BCAD=FALSE] at a resolution of 1 yr [yrsteps]
Ages were calculated every 0.125 [every] cm [depth], from 0 [dmin] to 403 [dmax] cm

Dates assumed outlying [outliers]: 2 (Surf:68-70) 4 (Tephra) 12 (D4:19-20)

Goodness-of-fit (-log, lower is better): 188.15
Any models with age-depth reversals were removed

Produced Tue Mar 13 12:12:26 2018

APPENDIX D: LITHIC ANALYSIS RAW MATERIAL

Initial Description	Raw Material Code	Quality	Rock Type	Surface texture (grain)	Light transmittance	Informal color	Cortex (if present-the informal color)	Color: texture	Inclusions	Relations
light bluish grey chert	C1	medium	chert	fine	moderately translucent	light blueish grey	N/A	varies, some dark lines throughout	dark inclusions	
light bluish grey chert	C2	medium	chert	moderate	moderately translucent	light blueish grey	light grey	uniform	flakey surface, rough-pocked surface	possibly same as C1 but not as smooth
very dark grey/black, maybe chert	C3	medium	dacite	fine	opaque	very dark grey, almost black	N/A	uniform	rough-pocked surfce in sections	
light greenish gray chert	Q1	low	chalcedony	coarse	opaque	blue and black	battered up, similar to interior	mottling, varied	scattered crystals	
light green/ forest green chert	C4	medium	chert	fine	opaque	light greenish gray		uniform		
light grey maybe chert	C5	high	chert	fine	moderately opaque	light green and forest green mixed		varies, sections of light and dark	fairly homogeneous other than colour change	possibly a higher grade piece of the C4 material
light grey mottled maybe chert	C6	medium	chalcedony	fine	translucent	light grey	similar to interior	varies, lighter and darker sections	banding due to breaks in material, flakey surface	
dark red maybe chert	B1	low	siltstone	moderate to coarse	opaque	very dark grey	NA	uniform	porous - small pockets that hold dirt	possibly lower grade of C3 or possibly a new material
light and dark grey chert	C7	medium	chalcedony	fine	translucent	light grey mottled	NA	mottling, light and dark inclusions	almost speckled light inclusions, breaks/lines that are darker	possibly similar to C6
light blue-grey chert	B2	medium	jasper	moderate to coarse	opaque	maroon	same as interior but smooth	uniform	rust	
light blue-grey chert	C8	low	jasper	fine to coarse	opaque	dark red		some light orange sections - could be thermal alteration		
light blue-green chert	C9	low	chert	moderate to coarse	opaque	light and dark grey		banding, varied	porous	
very dark grey maybe basalt	C10	medium	chert	very fine to coarse	variable	light blue-grey	NA	some dark banding and speckled sections	variable, some dark inclusions, some without	
maroon maybe basalt	C11	medium	chert	fine	moderately translucent	light blue-grey	cobble, similar to interior but rust colour overtop	fairly uniform with some dark banding and speckled sections - some more than others	scattered crystals	possibly a heat treated version of C10 but unsure, slightly darker and less blue
river cobble maybe basalt	B3	low	quartzite	very coarse	opaque	brown	brown	varies	large crystals	river cobbles
blue and black mottled maybe quartzite	C12	medium	chert	fine	moderately translucent	light blue-green	NA	mostly uniform,some variations between blue and green, some speckles of dark/black within	fairly homogeneous other than colour changes	close to green of C5 but has less lustre

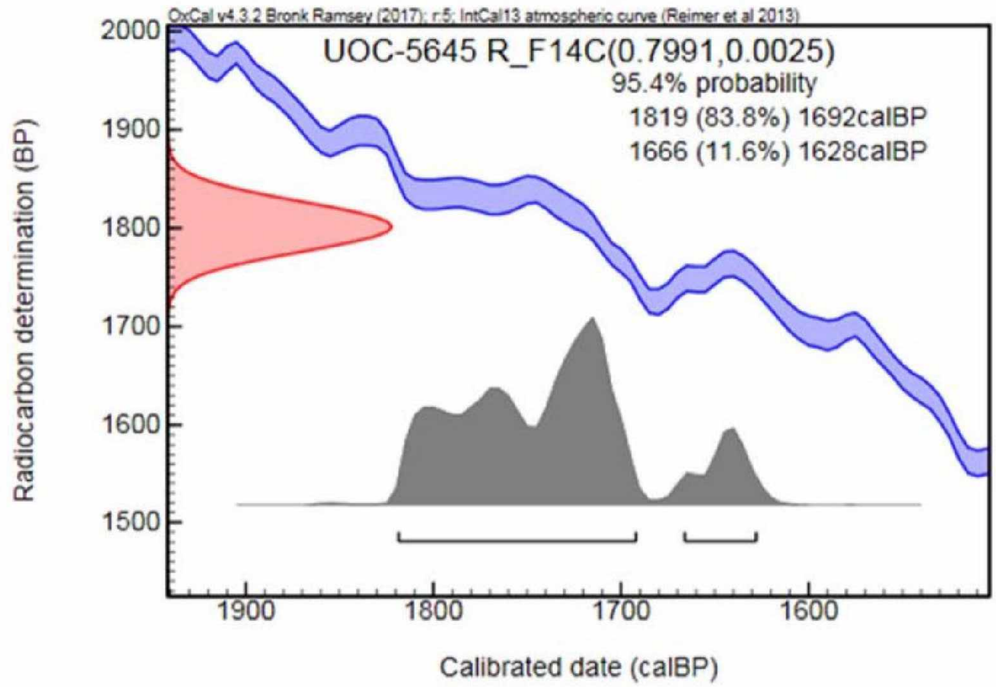
APPENDIX E: RADIOCARBON DATES - ARCHAEOLOGY SAMPLES

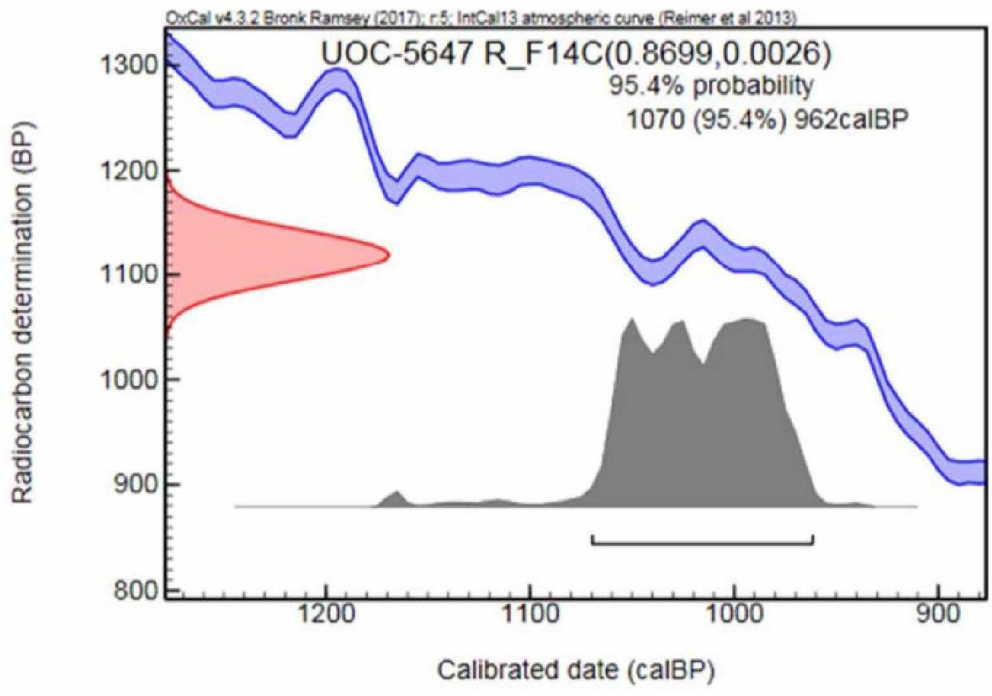
Table 1. Radiocarbon results. Calibration was performed using OxCal v4.2.4 (Bronk Ramsey, 2009) and the IntCal13 calibration curve (Reimer et al., 2013). Material codes are described in Crann et al. (2017).

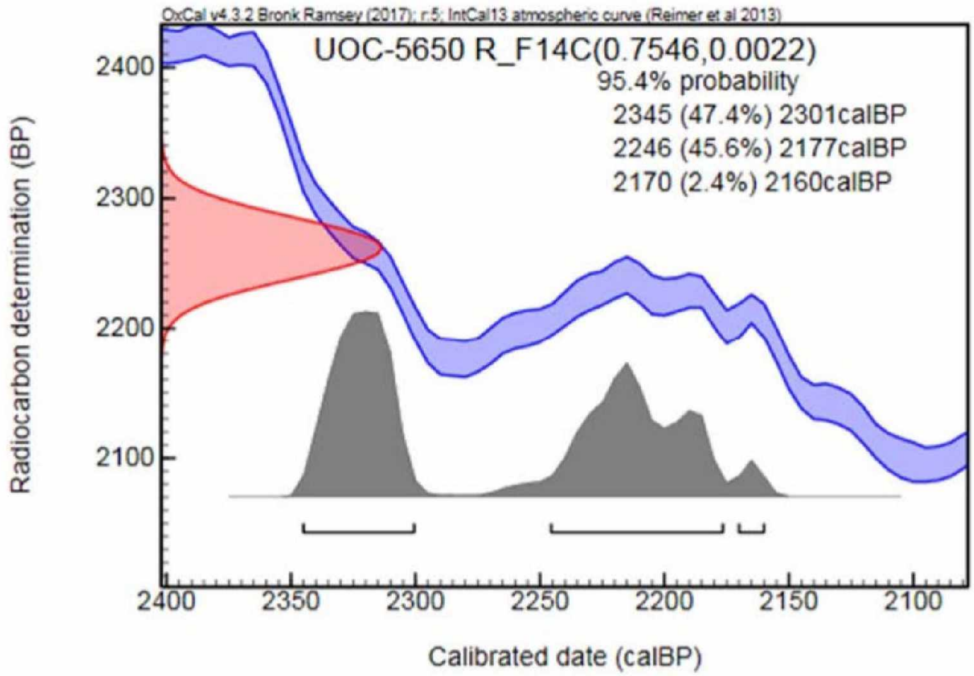
Lab ID	Submitter ID	Material	Mat. Code[a]	^{14}C yr BP	±	$F^{14}C$	±	cal BP
UOC-5645	LcVn-2: C1	bone	B, CN	1801	25	0.7991	0.0025	1819-1692 (83.8%) 1666-1628 (11.6%)
	LcVn-2: C2	*bone*	*B, CN*	*Failed – no collagen yield*				
UOC-5647	LcVn-2: C3	charcoal	AAA	1119	24	0.8699	0.0026	1070-962 (95.4%)
	LcVn-2: C4	*bone*	*B, CN*	*Failed – no collagen yield*				
	LcVn-2: C5	*bone*	*B, CN*	*Failed – no collagen yield*				
UOC-5650	LcVn-2: C6	charcoal	AAA	2262	23	0.7546	0.0022	2345-2301 (47.4%) 2246-2177 (45.6%) 2170-2160 (2.4%)
	LcVn-2: C7	*bone*	*B, CN*	*Failed – no collagen yield*				

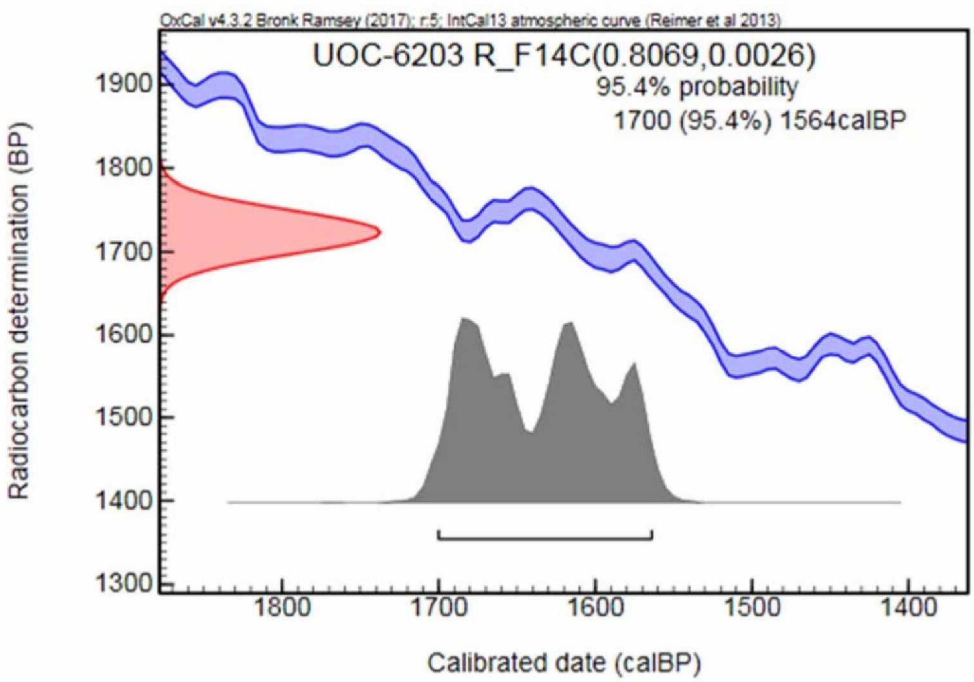
Table 1. Radiocarbon results. Calibration was performed using OxCal v4.3 (Bronk Ramsey, 2009) and the IntCal13 calibration curve (Reimer et al., 2013). Material codes are described in Crann et al. (2017).

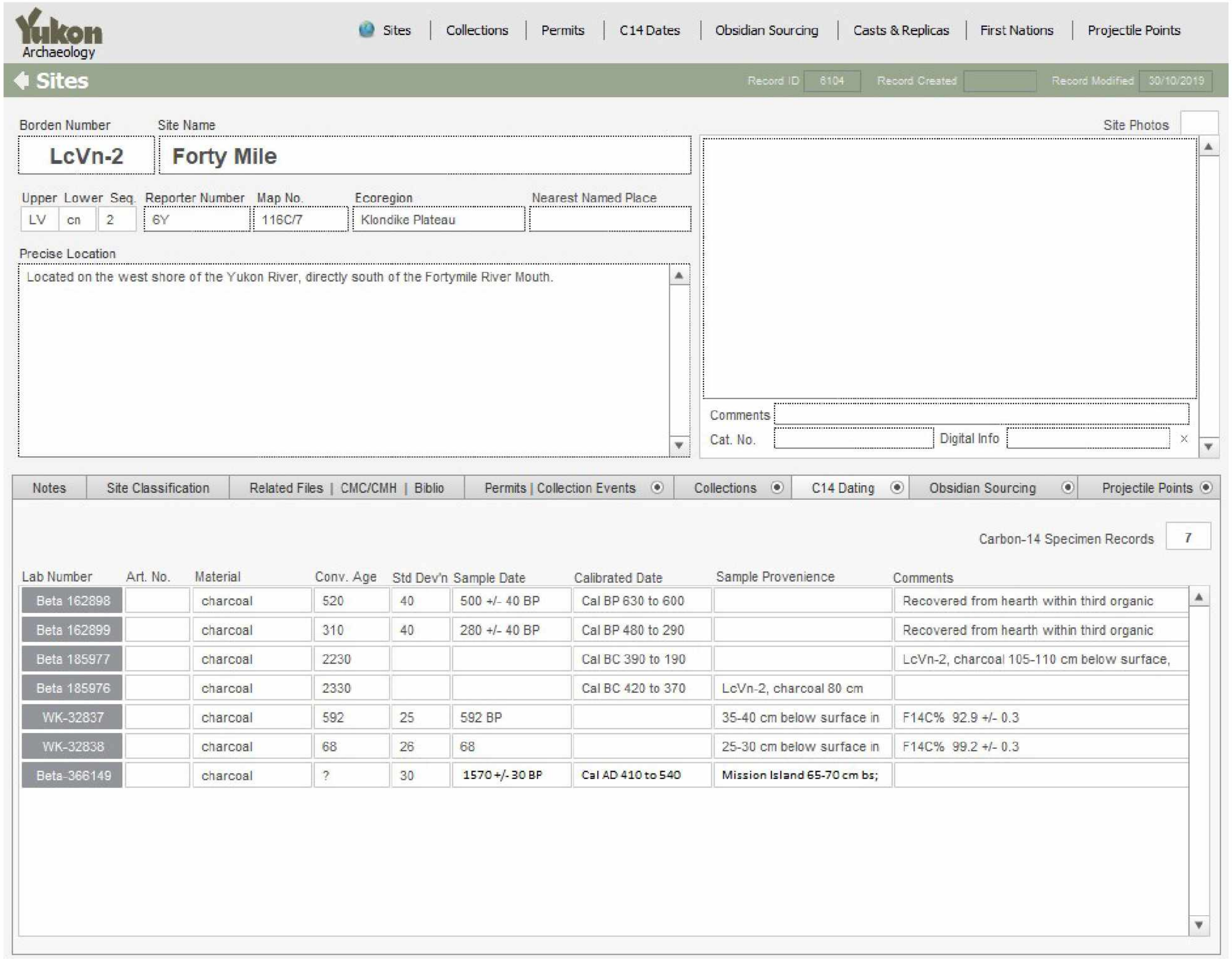
Lab ID	Submitter ID	Material	Mat. Code[a]	^{14}C yr BP	±	$F^{14}C$	±	cal BP
UOC-6203	LcVn-2: C8	Charcoal	AAA	1724	26	0.8069	0.0026	1700-1564 (95.4%)


OxCal v4.3.2 Bronk Ramsey (2017); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
UOC-5645 R_F14C(0.7991,0.0025)
95.4% probability
1819 (83.8%) 1692calBP
1666 (11.6%) 1628calBP
Radiocarbon determination (BP)
2000
1900
1800
1700
1600
1500
1900
1800
1700
1600
Calibrated date (calBP)


OxCal v4.3.2 Bronk Ramsey (2017); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
UOC-5647 R_F14C(0.8699,0.0026)
95.4% probability
1070 (95.4%) 962calBP
Radiocarbon determination (BP)
1300
1200
1100
1000
900
800
1200
1100
1000
900
Calibrated date (calBP)


OxCal v4.3.2 Bronk Ramsey (2017); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
UOC-5650 R_F14C(0.7546,0.0022)
95.4% probability
2345 (47.4%) 2301calBP
2246 (45.6%) 2177calBP
2170 (2.4%) 2160calBP
Radiocarbon determination (BP)
Calibrated date (calBP)


OxCal v4.3.2 Bronk Ramsey (2017); r:5; IntCal13 atmospheric curve (Reimer et al 2013)
UOC-6203 R_F14C(0.8069,0.0026)
95.4% probability
1700 (95.4%) 1564calBP
Radiocarbon determination (BP)
Calibrated date (calBP)



Yukon Archaeology

Sites | Collections | Permits | C14 Dates | Obsidian Sourcing | Casts & Replicas | First Nations | Projectile Points

Sites Record ID 6104 Record Created Record Modified 30/10/2019

Borden Number: **LcVn-2**
Site Name: **Forty Mile**
Site Photos

Upper	Lower	Seq.	Reporter Number	Map No.	Ecoregion	Nearest Named Place
LV	cn	2	6Y	116C/7	Klondike Plateau	

Precise Location
Located on the west shore of the Yukon River, directly south of the Fortymile River Mouth.

Comments
Cat. No. Digital Info

Notes | Site Classification | Related Files \| CMC/CMH \| Biblio | Permits \| Collection Events | Collections | C14 Dating | Obsidian Sourcing | Projectile Points

Carbon-14 Specimen Records 7

Lab Number	Art. No.	Material	Conv. Age	Std Dev'n	Sample Date	Calibrated Date	Sample Provenience	Comments
Beta 162898		charcoal	520	40	500 +/- 40 BP	Cal BP 630 to 600		Recovered from hearth within third organic
Beta 162899		charcoal	310	40	280 +/- 40 BP	Cal BP 480 to 290		Recovered from hearth within third organic
Beta 185977		charcoal	2230			Cal BC 390 to 190		LcVn-2, charcoal 105-110 cm below surface,
Beta 185976		charcoal	2330			Cal BC 420 to 370	LcVn-2, charcoal 80 cm	
WK-32837		charcoal	592	25	592 BP		35-40 cm below surface in	F14C% 92.9 +/- 0.3
WK-32838		charcoal	68	26	68		25-30 cm below surface in	F14C% 99.2 +/- 0.3
Beta-366149		charcoal	?	30	1570 +/- 30 BP	Cal AD 410 to 540	Mission Island 65-70 cm bs;	

```
CALIB RADIOCARBON CALIBRATION PROGRAM*
Copyright 1986-2017 M Stuiver and PJ Reimer

*To be used in conjunction with:
 Stuiver, M., and Reimer, P.J., 1993, Radiocarbon, 35, 215-230.

ACM5a
Beta 185976
Radiocarbon Age 2330±40
Calibration data set: intcal13.14c
# Reimer et al. 2013
One Sigma Ranges: [start:end] relative area
                  [cal BP 2310: cal BP 2379] 0.975361
                  [cal BP 2396: cal BP 2401] 0.024639
Two Sigma Ranges: [start:end] relative area
                  [cal BP 2182: cal BP 2237] 0.081428
                  [cal BP 2304: cal BP 2469] 0.91355
                  [cal BP 2477: cal BP 2484] 0.005021

ACM5b
UOC-5650
Radiocarbon Age 2262±23
Calibration data set: intcal13.14c
# Reimer et al. 2013
One Sigma Ranges: [start:end] relative area
                  [cal BP 2187: cal BP 2191] 0.04158
                  [cal BP 2206: cal BP 2230] 0.324791
                  [cal BP 2306: cal BP 2339] 0.633629
Two Sigma Ranges: [start:end] relative area
                  [cal BP 2160: cal BP 2170] 0.021833
                  [cal BP 2177: cal BP 2245] 0.474105
                  [cal BP 2301: cal BP 2345] 0.504062

ACM6
Beta 185977
Radiocarbon Age 2230±40
Calibration data set: intcal13.14c
# Reimer et al. 2013
One Sigma Ranges: [start:end] relative area
                  [cal BP 2159: cal BP 2253] 0.836671
                  [cal BP 2299: cal BP 2318] 0.163329
Two Sigma Ranges: [start:end] relative area
                  [cal BP 2151: cal BP 2336] 1.

ACM4b
UOC-6203
Radiocarbon Age 1724±26
Calibration data set: intcal13.14c
# Reimer et al. 2013
One Sigma Ranges: [start:end] relative area
                  [cal BP 1571: cal BP 1583] 0.113767
                  [cal BP 1600: cal BP 1631] 0.375625
                  [cal BP 1652: cal BP 1694] 0.510608
Two Sigma Ranges: [start:end] relative area
                  [cal BP 1564: cal BP 1700] 1.

ACM4a
Beta-366149
Radiocarbon Age 1590±30
Calibration data set: intcal13.14c
# Reimer et al. 2013
One Sigma Ranges: [start:end] relative area
                  [cal BP 1416: cal BP 1464] 0.602055
                  [cal BP 1479: cal BP 1501] 0.231921
                  [cal BP 1515: cal BP 1530] 0.166024
Two Sigma Ranges: [start:end] relative area
                  [cal BP 1409: cal BP 1545] 1.

ACM3
UOC-5647
```

```
Radiocarbon Age 1119±24
Calibration data set: intcal13.14c
# Reimer et al. 2013
One Sigma Ranges: [start:end] relative area
                  [cal BP 981: cal BP 1011] 0.491668
                  [cal BP 1021: cal BP 1038] 0.284741
                  [cal BP 1041: cal BP 1056] 0.223591
Two Sigma Ranges: [start:end] relative area
                  [cal BP 963: cal BP 1067] 1.

ACM2
WK-32837
Radiocarbon Age 592±25
Calibration data set: intcal13.14c
# Reimer et al. 2013
One Sigma Ranges: [start:end] relative area
                  [cal BP 550: cal BP 562] 0.218459
                  [cal BP 594: cal BP 636] 0.781541
Two Sigma Ranges: [start:end] relative area
                  [cal BP 540: cal BP 569] 0.270187
                  [cal BP 582: cal BP 650] 0.729813

CFL3a
Beta 162898
Radiocarbon Age 520±40
Calibration data set: intcal13.14c
# Reimer et al. 2013
One Sigma Ranges: [start:end] relative area
                  [cal BP 511: cal BP 552] 0.961952
                  [cal BP 614: cal BP 617] 0.038048
Two Sigma Ranges: [start:end] relative area
                  [cal BP 503: cal BP 561] 0.781516
                  [cal BP 595: cal BP 635] 0.218484

CFL3b
Beta 162899
Radiocarbon Age 310±40
Calibration data set: intcal13.14c
# Reimer et al. 2013
One Sigma Ranges: [start:end] relative area
                  [cal BP 306: cal BP 332] 0.251707
                  [cal BP 355: cal BP 433] 0.748293
Two Sigma Ranges: [start:end] relative area
                  [cal BP 297: cal BP 477] 1.

Ranges marked with a * are suspect due to impingment on the end of the calibration data set

# Reimer PJ, Bard E, Bayliss A, Beck JW, Blackwell PG, Bronk Ramsey C, Buck CE
# Cheng H, Edwards RL, Friedrich M, Grootes PM, Guilderson TP, Haflidason H,
# Hajdas I, Hatté C, Heaton TJ, Hogg AG, Hughen KA, Kaiser KF, Kromer B,
# Manning SW, Niu M, Reimer RW, Richards DA, Scott EM, Southon JR, Turney CSM,
# van der Plicht J.
# IntCal13 and MARINE13 radiocarbon age calibration curves 0-50000 years calBP
# Radiocarbon 55(4). DOI: 10.2458/azu_js_rc.55.16947
```